United States
Environmental Protection Agency

Resource Conservation and Recovery Act (RCRA) Multi-Year Research Plan: Fiscal Years 2003 to 2010

U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC 20460

May 2004

This research plan has not yet been peer-reviewed.

Table of Contents

Major Acronym List

APG	annual performance goal	OSW	Office of Solid Waste
APM	annual performance measure	OSWER	Office of Solid Waste and Emergency Response
BDAT	best demonstrated available treatment	ORD	Office of Research and Development
BIF	boiler and industrial furnace	PBT	persistent bioaccumulative toxic
CA	corrective action	PCB	polychlorinated biphenyl
CEAM	Center for Exposure Assessment Modeling	PCDD	polychlorinated dibenzodioxins
CEM	continuous emissions monitoring	PCDF	polychlorinated dibenzofurans
CERCLA	Comprehensive Environmental Response Compensation and Liability Act	PM	particulate matter
DNAPL	dense non-aqueous phase liquid	QSAR	quantitative structure activity relationships
FRAMES	Framework for Risk Analysis in Multimedia Environmental Systems	RCC	Resource Conservation Challenge
FY	fiscal year	RCT	Research Coordination Team
GPRA	Government Performance and Results Act	RCRA	Resource Conservation and Recovery Act
GW	ground water	REMPI	resonance enhanced multi-photon ionization
HSWA	Hazardous and Solid Waste Amendments	RSA	Regional Sensitivity Analysis
HWC	hazardous waste combustors	SA/UA	sensitivity analysis/uncertainty analysis
HWIR	Hazardous Waste Identification Rule	SAB	Science Advisory Board
ITRC	Interstate Technical Regulatory Cooperation	SuperMUSE	Supercomputer for Modeling Uncertainty and Sensitivity Evaluation
LHS	latin hypercube sampling	SW	surface water
LTG	long-term goal	TCLP	toxicity characteristic leaching procedure
MACT	maximum achievable control technologies	TIO	Technology Innovation Office
MCL	maximum contaminant level	TOE	total organic emissions
MDM	multimedia decision-making	TSDE	tree-structured density estimation
MOU	memorandum of understanding	UCPR	uniform coverage with probabilistic rejection
3MRA	Multimedia, Multireceptor, Multipathway Risk Assessment	VI	vapor intrusion
MYP	multi-year plan	VOC	volatile organic contaminant
NCER	National Center for Environmental Research	WDP	waste-derived product
NCEA	National Center for Environmental Assessment	WM	waste management
NERL	National Exposure Research Laboratory	WMPC	Waste Minimization Priority Chemical
NRMRL	National Risk Management Research Laboratory		
OAQPS	Office of Air Quality Planning and Standards		

Resource Conservation and Recovery Act (RCRA)
Multi-Year Research Plan:
Fiscal Years 2003 to 2010

1. Introduction

The Office of Research and Development (ORD) uses multi-year planning to direct our research program over a period of five to ten years. This approach promotes ORD's focus on the highest priority issues and provides a coordinated approach for contributing to the achievement of Agency goals.

The purpose of the Multi-Year Plans (MYPs) is to provide a framework integrating research across ORD's Laboratories and Centers and Government Performance and Results Act (GPRA) goals in support of the Agency's mission to protect human health and to safeguard the natural environment. The MYP is composed of three parts: 1) a narrative description of the plan, 2) flow diagrams to show the sequence and interrelationship of our annual performance goals (APGs) in achieving each long-term goal (LTG) and 3) tables describing the APGs and associated annual performance measures (APMs) needed to meet our long-term goals. The MYP tables relate the APMs/outputs in a particular year with the APGs they support, even if the APG is in an out year. The budget is assumed roughly constant at approximately $10 million annually from FY03 through FY10.

By identifying the impact of potential annual planning decisions, MYPs will aid in the evaluation of research options and will foster the integration of strategic risk-based environmental protection and the anticipation of future environmental issues. They also allow for a more comprehensive understanding of changes needed to emphasize a new direction or accelerate an existing program. The Program Offices and Regions were part of the writing teams that updated these plans; as key users of ORD research products, it is critical that their perspectives are addressed. MYPs are intended to be living documents and will be updated approximately biennially to reflect changes in Agency strategic thinking, program and regional office priorities, available resources, and the current state of the science.

The Resource Conservation and Recovery Act (RCRA) Multi-Year Plan describes FY03-10 research in support of Agency Goal 3, ***"Preserve and Restore the Land."*** This is the second version of the plan, neither of which have undergone peer review to date. The goal states[1]: Preserve and restore the land by using innovative waste management practices and cleaning up contaminated properties to reduce risks posed by releases of harmful substances. Three objectives within Goal 3 (see Appendix A) address the RCRA program:

Objective 3.1: Preserve Land. By 2008, reduce adverse effects to land by

[1]2003-2008 EPA Strategic Plan, September 2003, EPA-190-R-03-003, http://www.epa.gov/ocfo/plan/2003sp.pdf

reducing waste generation, increasing recycling, and ensuring proper management of waste and petroleum products at facilities in ways that prevent releases

Objective 3.2: Restore Land. By 2008, control the risks to human health and the environment by mitigating the impact of accidental or intentional releases and by cleaning up and restoring contaminated sites or properties to appropriate levels

Objective 3.3: Enhance Science and Research. Through 2008, provide and apply sound science for protecting and restoring land by conducting leading-edge research and developing a better understanding and characterization of environmental outcomes under Goal 3

2. Background

Legislative History

The Solid Waste Disposal Act of 1965 was the first law to require safeguards and encourage environmentally sound disposal methods for household, municipal, commercial, and industrial refuse. Congress amended this law in 1970, the Resource Recovery Act, and again in 1976, with the Resource Conservation and Recovery Act. Congress revised RCRA in 1980 and 1984. The 1984 amendments, the Hazardous and Solid Waste Amendments (HSWA), significantly expanded the scope of RCRA. The major subtitles are

- Subtitle C - establishes a program for managing hazardous waste from generation to ultimate disposal, including the clean up of sites contaminated by hazardous waste spills and other releases to the environment.
- Subtitle D - establishes a program for managing solid (primarily nonhazardous) waste, such as household waste.

Section 6902 of RCRA (42 USC 82 Subchapter I, Sec. 6902 (a)) describes the intent of Congress to promote the protection of health and the environment and the role of research by:

- "promoting a national research and development program for improved solid waste management and resource conservation techniques, more effective organizational arrangements, and new and improved methods of collection, separation, and recovery, and recycling of solid wastes and environmentally safe disposal of non-recoverable residues;" and
- "promoting the demonstration, construction, and application of solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of air, water, and land resources."

RCRA as amended by HSWA has led to significant regulatory programs for the safe management of hazardous and non-hazardous wastes. The Agency is increasingly focusing on improvements to the regulatory framework based on the most current science and greater

emphasis on resource recovery. In addition, legislation mandates that EPA require the investigation and cleanup, or remediation, of these hazardous releases at RCRA facilities. This program is known as RCRA Corrective Action (CA). EPA enforces RCRA CA primarily through statutory authorities established by HSWA.

Current Priorities of the Office of Solid Waste and Emergency Response

The Office of Solid Waste and Emergency Response (OSWER) set six priorities for FY03 (http://www.epa.gov/oswer/Mission.htm), a number of which have also reached the Administrator's agenda for the Agency. These include partnerships with states, municipalities and the private sector to encourage waste minimization, recycling, and "beneficial reuse" of wastes and products. The importance of these activities to the Agency is further highlighted by the Science Advisory Board's (SAB's) recent "Commentary on Industrial Ecology"(April 2002) in which the SAB emphasizes recycling, re-use and related topics in their recommendations to the Administrator.

Five of the six priorities have research needs that fit well with ORD's research capability:

- Counter-Terrorism: Refer to the National Homeland Security Research Center (NHSRC) research strategy for ORD activities to support OSWER and Regional research needs in Homeland Security (waste disposal and analytical issues).
- Revitalization: Broadly promote the lessons learned by the Brownfields program and how revitalization can complement our traditional cleanup programs and lead to faster cleanups. See the Contaminated Sites MYP for related ORD Brownfields activities.
- One Cleanup Program: Create a national dialogue on the future of Superfund and other waste/cleanup programs.
- Recycling and Energy: Promote recycling and energy for both hazardous and non-hazardous wastes. See the Resource Conservation Challenge as described below.
- Retail Initiative: Connect with consumers and households to get them focused on making purchasing decisions that are better for the environment and create interest in the environment, while promoting environmental stewardship at the manufacturing level. See the Pollution Prevention MYP for details on ORD's activities in industrial ecology, green chemistry and engineering, etc., and see also the Resource Conservation Challenges described below.

Separately, the Office of Solid Waste (OSW) engaged in a process of developing a vision of the future of the RCRA program. Two documents, The *Draft OSW Strategic Plan* of October 2002 and *Beyond RCRA: Prospects for Waste and Materials Management in the Year 2020* describe a future program where there are three goals. These goals were endorsed by the Assistant Administrator of OSWER,[2] and are: (1) reduce waste and increase the efficient and sustainable

[2]Memorandum from Marianne Horinko to the RCRA Vision Paper Steering Committee and RCRA Vision Workgroup dated October 17, 2002

use of resources; (2) prevent exposures to humans and ecosystems from the use of hazardous chemicals; and (3) manage waste and clean up chemical releases in a safe, environmentally sound manner. In this vision, humans and the environment are protected while the removal of barriers to recycling and reuse are explored. In addition to remediating past releases of hazardous chemicals, the importance of returning idle or underutilized properties to productive use is recognized.

The Resource Conservation Challenge

As a way to enhance recycling and energy conservation, OSW established the Resource Conservation Challenge (RCC) on September 9, 2002. The RCC strives to reduce waste by promoting the reuse of recycled products to conserve natural resources, reduce greenhouse gas emissions, save energy and ultimately preserve our ecosystems. The RCC positions the Agency in a leadership role in fostering significant national progress toward reducing the amount of waste going to landfills; reducing the amount of hazardous and non-hazardous wastes generated; increasing recycling; cultivating opportunities for converting waste to energy and raw materials (e.g., by piloting new cleaner technologies, such as gasification, which convert waste into a gas that can be burned as fuel); and ensuring that wastes and petroleum products are safely and appropriately managed to prevent future contamination of the land.

This major national effort is being carried out by a variety of activities that involve businesses, manufacturers, and consumers that include: forming voluntary partnerships for waste minimization, providing infrastructure development that makes it easier to meet RCC goals, technical support and outreach to various organizations, engaging youth, and educating people. OSWER has established a set of demonstration projects for reducing waste and recovering energy, and has provided ORD with a list of research needs to support key areas such as a rule-making that would allow wastes to be used where appropriate as a type of fuel in essentially closed "gasification" systems; partnerships to encourage waste reduction and recycling, e.g. in the areas of electronic wastes and carpeting; bioreactors to more efficiently manage municipal waste streams; and beneficial reuse of waste derived products such as roadbed.

Summary of OSW and Regional Needs for ORD Research

In December 2002, OSW provided a thorough compilation of research needs (Appendix B), as did the Regions (Appendix C), and States (Appendix B, Item 3), for use in revising this multi-year research plan. OSW's research needs stress the equal importance of both emerging research areas and "core" research activities that focus on hazardous chemicals. They also emphasize the need for technical support for corrective action and combustion. The State needs strongly reinforce the importance to the Agency of research in waste management technologies and resource conservation challenges, and also reinforce the importance of an appropriate degree of technical support activities. The regions' needs also emphasize the importance of research deliverables that support program implementation and the solution of problems, not just the identification of problems.

Emerging research topics that are receiving increased emphasis within OSW and the Regions

include resource conservation programs (e.g., beneficial reuse of waste, electronics waste recycling and waste minimization), homeland security (needs are expected to be funded through the new Homeland Security Research Center), vapor intrusion, risk assessment, and analytical method support. OSW noted that to address emerging research topic needs ORD will need to continue emphasizing a multi-program approach, and that the Waste Research Coordination Team (RCT) needs to leverage extensively with other RCTs and other programs, especially Superfund and Pollution Prevention. For example, waste minimization and green chemistry topics concerning targeted reductions in use of 30 Waste Minimization Priority Chemicals (WMPCs) should be a high priority for funding under pollution prevention; and development of analytical methods should be closely coordinated with Superfund.

Ongoing research topics: The ongoing research that underpins current applications technology and anticipates OSW long-term needs remains essential to this program. Because these needs have been identified by OSW, they are unique to RCRA; and hence, they are not funded under other programs or RCTs. The research, development and technical support components of this work may be grouped into three main areas: waste management, waste-related multimedia science, and corrective action technical support. Waste management research needs include hazardous waste combustion topics (e.g., risk identification and technology development), improved understanding of leaching mechanisms and definition of representative analytic methods (which is critical for both the RCRA and CERCLA programs), treatment technology for hard-to-treat wastes, notably arsenic and mercury, and liners.

Multimedia science and modeling also remains a need for use in a variety of national, regional and site-specific applications. One major tool that ORD is developing to support this need is the Multimedia, Multireceptor, Multipathway Risk Assessment (3MRA) model. Future directions in the development of multimedia modeling will depend on the recommendations of the Science Advisory Board, who conducted a review of the modeling system in FY03. The schedule and effort to improve the science, technology and data for use in multimedia modeling will depend on the outcome of the SAB review and client needs.

Support for corrective action at RCRA sites is an important component of the ORD program. EPA estimates that over 6500 facilities are potentially subject to RCRA corrective action statutory authority.[3] The contamination resulting from RCRA facility releases poses potentially significant risk to human health and the environment, in a manner very similar to that found at Superfund sites. Most of ORD's research efforts on corrective action address three areas: 1) ground water to indoor air contamination, 2) ground water/surface water interactions, and 3) natural attenuation of metallic contaminants. An important component of the ORD program is technical support through the Ground Water, Engineering, and Monitoring/Characterization Technical Support Centers.

---

[3] See the EPA Corrective Action web site at http://www.epa.gov/epaoswer/hazwaste/ca/backgnd.htm for more information.

3. Development of the Research Program

ORD developed a research program to address the core research needs of the RCRA program[4], and as new needs have emerged (see Appendix B), ORD has adapted the program to address the shifting priorities. The program as a whole is described in this section and the next, but to highlight changes in the research program that are beginning in early 2003, a special section then follows describing shifts to address new priority areas.

Figure 1 shows a logic diagram[5] that summarizes the features of the research program. As read from right to left, the model describes the long-term outcomes of the RCRA program (the "clients"). The OSW statement of research needs indicate areas within this framework where ORD should direct its efforts. Nine areas of focus are indicated as intermediate outcomes on the logic diagram. These are listed to indicate how ORD is dividing its effort and has developed its research program. The nine areas are beneficial reuse of waste, waste minimization priority chemicals, vapor intrusion from contaminated ground water to indoor air, landfill liners/covers, landfill bioreactors, waste leaching, combustion emissions, multimedia modeling approaches to decision-making, and corrective action technical assistance. Generally, the thrust of work in each area is to provide OSW with better information for decision-making or improved assessment (note: resources are not allocated equally to each area).

Because of common elements between these research areas, ORD has developed two long-term goals (LTGs) to meet the needs of the RCRA program, including corrective action: waste management and multimedia decision-making. All nine areas fall into one of these LTGs. The rationale for the ORD LTGs and each research area is given below. ORD's short term outcomes or the annual performance goals are also stated for each of the nine research areas. The research activities that support the goals include laboratory and field studies, development of measurement techniques, development and evaluation of models, and generation and assessment of exposure scenarios. The products produced include reports, synthesis reports, papers, guidance, fact sheets, software and user's guides and technical support. These products ~~are distributed to EPA and the~~ interested community through the ORD annual products lists,

[4] In addition to using the GPRA Goals and Objective, discussion and written input from OSW (Appendix B) and the Regions (Appendix C), the following references have been used in developing the research plan:

1. Waste Research Strategy, 1999, EPA/600/R-98/154.
2. A National R&D Strategy for Toxic Substances and Hazardous and Solid Waste, the Committee on Environment and Natural Resources, 1995.
3. Office of Research and Development Strategic Plan, January 2001, EPA/600/R-01/003.
4. Multi-Year Plan: Pollution Prevention and New Technologies for Environmental Protection, 2001.
5. Beyond RCRA: Prospects for Waste and Materials Management in the Year 2020 White Paper, August 2002, EPA530-R-02-009.
6. Office of Solid Waste Strategic Plan 2003-2008, 10/02/02 Working Draft.
7. U.S. Environmental Protection Agency, Strategic Plan for Homeland Security, September 2002.
8. ORD Laboratory and Center plans (e.g., task descriptions) and staff input, activities at other Agencies, and a variety of other sources of information.

[5] McLaughlin, J.A. and G.B. Jordan, 1999, Logic models: a tool for telling your program's performance story, Evaluation and Program Planning, 22, 65-72.

document distribution centers, ORD-sponsored seminars, presentations at the RCRA National Meeting and other scientific conferences, ORD's Center for Subsurface Modeling Support and Center for Exposure Assessment Modeling (CEAM), ORD scientist participation in Agency rule-making and guidance development workgroups, through the ORD technical support centers, and by informal technical support provided by ORD scientists and engineers.

Based on information in the Introduction and Background sections and on ORD's capability and capacity to meet OSW/Regional priority RCRA research needs, two primary topics were identified: waste management options and multimedia decision making. ORD's work is housed under long-term goals written for these topics and includes elements of RCRA corrective action and resource conservation, which are noted in the following discussion. Because each long term goal is strongly tied to specific needs of the program and regional offices, ORD views the work as a whole to be problem-driven in nature. The material to follow includes background and drivers of the program, science questions, progress to date, the critical path to achieving the long-term goal, and the planned work from FY03 to FY10.

Figure 1. Logic Model Encapsulating the ORD RCRA Research Program

Outreach and Effective Transfer

Tech transfer through Centers, guidance, fact sheets, workshop, synthesis reports, software and user's guides

Resources	Activities	Outputs*	Clients	Short Term Outcomes*		Intermediate Outcomes	Long-Term Outcomes
ORD resources: $10 Million 50.3 FTE Leveraging with other Agencies: Departments of Defense and Energy, Nuclear Regulatory Commission, States, Private Sector, Trade Associations	Perform research on: 1) beneficial reuse of waste 2) impacts of reducing usage of priority chemicals 3) vapor intrusion of contaminants into buildings 4) landfill liners and covers 5) landfill bioreactors 6) leaching 7) combustion and incineration 8) multimedia modeling 9) provide technical support for RCRA corrective action sites	1) Assessment of impacts of beneficial reuse of waste 2) Assessment of environmental improvement due to reduction in priority chemical usage 3) Review of existing vapor intrusion models 4) Report on Construction Testing for Improved Liner Performance 5) Landfill Bioreactor Performance Syn. Report 6) Syn. Report on leaching issues 7) Papers on co-gasification and measurement of trace organics emissions 8) Prepare technical documentation for SAB review 9)Tech support center reports	Direct Clients: 1) Office of Solid Waste 2) EPA Regions Indirect Clients: 3) States 4) Private Sector	1) Conduct assessment of WMPCs 2) Expanded application of risk assessment for beneficial reuse of waste 3) Support RCRA applications, including vapor intrusion 4) Evaluate liner/cover performance through four reports 5) Assessment of First Generation Landfill Bioreactors 6) Assessment of leaching 7) Research approach for emissions at Subpart X facilities 8) Deliver multimedia modeling system to OSW 9) Tech support for CA	**LTG-1** Improve waste management for industrial and municipal wastes to enhance sustainability by providing technical reports, and technical support. **LTG-2** Support scientifically defensible and consistent decision-making for RCRA waste management and corrective action by providing a tested multimedia modeling system, technical reports, and technical support.	1) Improved decisions on beneficial reuse of waste 2) Assessment of progress toward environmental improvement from reduction in priority chemicals 3) Knowledge of alternatives proposed for vapor intrusion modeling 4) Better approaches to landfill liners 5) Better decision-making on use of landfill bioreactors 6) Improved leaching tests 7) Better assessment of combustion emissions 8) Improved decisions on future of multimedia modeling 9) Better response at corrective action sites	**Conserving Natural Resources**: Contributing to a system where economic prosperity co-exists with a healthy environment **Preventing Future Waste Problems:** Sustaining the Momentum for Safe Management **Cleaning up Problems from Past Practices**

*Key or representative outputs and outcomes listed of each research topic; see Tables 1 and 2 for complete listings of APMs and APGs

Multimedia Decision-Making Long Term Goal

Rationale behind the goal

RCRA multimedia decision-making spans problem scales and include site-specific assessments needed for corrective action sites and national scale assessments. The multimedia decision-making goal is intended to support scientifically defensible and consistent decision-making for RCRA waste management and corrective action:

> **Multimedia Decision-Making LTG: Support scientifically defensible and consistent decision-making for RCRA waste management and corrective action by providing a tested multimedia modeling system and technical support to those who use the model to make environmental decisions.**

This goal addresses multimedia environmental assessments. At corrective action sites, currently identified problems include ground water/surface water interactions and their impacts on contaminant transport and transformation. Vapor intrusion of contaminants from subsurface contamination into indoor air is another contemporary, difficult multimedia problem that is addressed by research in this LTG. At a larger scale, nationwide multimedia assessments that account for contaminants originating from various RCRA waste management units are needed for development or refinement of regulations or guidance. Depending upon the nature of the chemicals involved, the assessment may need to consider exposure pathways that include air, water, and land, simultaneously. These approaches are also appropriate for nationwide assessment of beneficial reuse of waste, and to determine the benefits of reduction in use of waste minimization priority chemicals. These issues are housed under the same goal, because they all involve problem analysis, appropriate data collection, multimedia assessment, and communication of results.

ORD Program Shifts to Accommodate Emerging Research Priorities of OSWER

Components of the multimedia modeling program have been active for several years in response to nationwide assessment needs to support the development of regulations. With newly expressed needs, however, a portion of the existing multimedia research program is being redirected to respond to those priorities, particularly in the area of resource conservation. ORD already has work underway under the Waste Management LTG discussed below that addresses one of these needs: landfill bioreactors. ORD is now expanding its efforts to create a multi-laboratory multimedia research program to address aspects of these needs. Important resource conservation goals are also addressed through the Pollution Prevention MYP as that plan addresses Agency-wide pollution prevention objectives. What can be achieved under the RCRA MYP represents only a modest portion of the total need.

Resources are being redirected into three areas of resource conservation and one of corrective action. The three resource conservation areas are: beneficial reuse of waste, electronics wastes recycling, and waste minimization priority chemicals (WMPCs or simply “priority

chemicals")[6]. The corrective action area is vapor intrusion (VI) evaluation. These areas were selected because they are high priority program office needs for resource conservation (one of the OSWER Assistant Administrator's six priorities); they build on existing work within this MYP (i.e., preliminary work on beneficial reuse of waste); they capitalize on the efforts in other goals (i.e., WMPCs); and they expand the work into another area of need (electronics waste recycling). In many cases, these efforts are particularly suited to initial risk assessments using existing screening models, and later will be applicable to topics in the national scale risk assessment capabilities that are expected to mature in the next 4 to 5 years. Each of these efforts is associated with short-term and long-term efforts, moving from reports on the evaluation of the state-of-the-science, through risk assessment screening via existing models for use in decision-making and prioritization, to national multimedia risk assessments in some cases.

Most of the multimedia modeling disinvestment is in activities related to the Hazardous Waste Identification Rule (HWIR). Specific disinvestments were made in the development of enhanced source-term models for 3MRA, 3MRA multi-source/multi-chemical assessment capability at waste disposal sites, and in the use of 3MRA for a national scale risk assessment for the hazardous disposal of 43 chemicals. Depending on the SAB comments and OSW needs, development of these capabilities may be restored in future versions of the MYP.

Waste Minimization Priority Chemicals: Specific WMPCs are identified in the Pollution Prevention MYP where the focus is on the replacement or minimized use of these chemicals in the industrial sector. To complement this work, priority chemical efforts in this MYP focus on assessing the potential for risk reduction resulting from decreased priority chemical use. A modeling plan developed in FY 03 will be implemented to meet a near term APM (FY 05) to demonstrate the effectiveness of reducing the use of 30 targeted priority chemicals. This risk assessment will use an existing data set for 8 of the 30 chemicals and result in a powerful tool for evaluating the effectiveness of this program in reducing risk to human health and the environment. This work needs to be heavily leveraged with work in the Pollution Prevention MYP.

Beneficial reuse of waste: ORD has conducted a preliminary evaluation of the major waste-derived products in the marketplace. The goal of the new work will be to prioritize these products based on impact (exposure and toxicity), identify gaps, fill data needs through mining of existing databases or measurement, conduct risk assessments, and ultimately develop decision support products based on nationally-scoped, multimedia capabilities. The research and development activities described here will be reassessed as this evaluation is continuously refined through ORD-OSW dialog.

Electronics wastes recycling: This is a new area of investment for this MYP. Sampling ~~strategies for extremely hetero~~geneous wastes, such as electronics or demolition wastes, pose

[6] EPA's list of 30 Waste Minimization Priority Chemicals (WMPCs) replaces the list of 53 chemicals EPA identified in its 1998 Federal Register "Notice of Availability: Draft RCRA Waste Minimization Persistent, Bioaccumulative and Toxic (PBT) Chemical List (Federal Register: November 9, 1998. Volume 63, Number 216. Page 60332-60343).

unique problems in the identification and collection of representative samples. This work will focus initially on identification of the typical components of electronics wastes, and then on the development of sampling guidance and risk screening for heterogeneous electronics wastes.

Vapor Intrusion: The commonly used Johnson-Ettinger model is based upon a series of simplifying assumptions and has been criticized both for under-predicting and over-predicting vapor concentrations. Alternate formulations and the conditions under which they would be applied will be evaluated. This work will include a review and critique of existing models for this problem in FY03. In FY04 a set of the evaluated models will be provided for evaluation and determination of generic worst case parameter sets. This work is designed to complement previously existing APMs for vapor intrusion and additional work to address sub-slab vapor sampling, recommendations for soil gas monitoring and an assessment of the potential impact of the vapor pathway on indoor air.

Additional Work That Could Address RCRA Program Needs

Through discussion with OSW, ORD identified a set of additional work that could enhance the research program. This additional work is described in the section below, titled "Potential Additions to the Research Program." In that section research and development is described that addresses:

- aspects of pollution prevention, sustainable production and use of materials, and life-cycle analyses of materials and products
- additional work on "conventional" waste management that is an unmet OSW need
- additional needs for RCRA corrective action
- sampling and analytical needs for various waste streams

This proposed work could provide the basis for future activities either through additional funding or as shifts in the current program as other work is completed.

Principal Areas of Research Activity

The components of the multimedia decision-making long term goal include site-specific RCRA corrective action, multimedia modeling for nationwide assessments and other applications. These are described below.

Site-Specific Corrective Action (CA)

A portion of ORD's research and technical assistance for Corrective Action falls under the long term goal of Multimedia Decision-Making. Support for corrective action at RCRA sites is an important component of the ORD program. Most of ORD's research efforts on corrective action address three research areas: 1) ground water to indoor air contamination, 2) ground water/surface water interactions, and 3) natural attenuation of metallic contaminants. An important component of the ORD program is technical support through the Ground Water, and

Engineering and Characterization Technical Support Centers. The placement of this work in the Multimedia Decision-Making LTG was made, because the bulk of the ORD work on corrective action address multimedia contamination problems.

OSW and the Regions rely where possible on Contaminated Sites research to address the needs of the corrective action program. Certain RCRA corrective action research needs are not already addressed through the Contaminated Sites MYP and are addressed in this plan.

Also, the Contaminated Sites Multi-Year Plan has extensive work that supports assessment and clean-up of contaminated sites. In that plan work on contaminated ground water is divided into four "threads," namely: dense nonaqueous phase liquids (DNAPLs), inorganic contaminants, leaking underground storage tank sites with light nonaqueous phase liquid sources and fuel oxygenates, and complex hydrogeology and overlooked transport paths. Work on soils includes development and evaluation of: laboratory and field analytical methods, sampling methods, sampling designs, remediation technologies, models for characterization, assessment, fate, and transport, risk management, and assessment of effects of mining wastes on soils.

Multimedia Modeling for Nationwide and Other Assessments

ORD has had a mandated role to play in developing the tools for performing multimedia assessments, partly because the Science Advisory Board requested ORD's participation after a 1995 review of OSW's work-to-date on the HWIR. Although ORD and OSW worked together prior to this time on smaller-scale, somewhat-similar assessments, ORD and OSW began development in 1997 of a joint approach to using multimedia modeling for nationwide assessments of contaminant behavior for setting regulatory limits on waste disposal. This work was based on an extensive needs review involving direct communication with Program Offices, several Regional Offices and several States. The review focused on the existing and potential roles of multimedia modeling in regulatory activities. The overwhelming conclusions of the assessment were that 1) multimedia modeling is fundamental to the regulatory and decision-making processes and, 2) the decision-making community was struggling with a myriad of incompatible technologies and inconsistent science. Because of these findings, this research was made an important component of ORD's base research program for OSWER.

The resulting technology included both an infrastructure component named the Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) and the initial set of models, named the Multimedia, Multireceptor, Multipathway Risk Assessment (3MRA) model. This project represented a unusual partnership between ORD and a program office as both ORD and OSW contributed staff and extramural funds to the work. ORD's unique expertise in this area included lessons learned from the prior assessments, the surface water and air transport modules, chemical parameter estimation, metal speciation, and design and implementation of the modeling framework.

Multimedia decision-making research needs stated by OSW (Appendix B, item 5) include activities required to complete the FY03/04 Science Advisory Board review that will address Congressional limitations set on the use of the Multimedia, Multireceptor, Multipathway Risk

Assessment modeling system. The direction of future research and development to support multimedia decision-making is contingent upon the SAB report and evolving OSW needs. Since the results of the SAB review are not available for this revision of the RCRA MYP, the multimedia modeling planning is addressed in the following way: With the exception of significant near-term resource shifts to accommodate resource conservation needs, the multimedia modeling work described below is contingent on the guidance provided at the completion of the SAB review. The next update to the MYP will reflect the results of the SAB review. Although a final HWIR rule was promulgated in April 2001, the need for ongoing research and development of multimedia modeling continues. The mandate to develop technically sound methods for establishing national risk-based exit levels supporting decisions related to hazardous waste systems, beneficial reuse of resources, and pollution prevention efforts still exists. As proposed previously in this plan, however, shifts to new priorities will provide the basis for further changes in the program where warranted.

Through development of an integrated multimedia modeling technology, the work seeks to define a flexible, multidisciplinary capability for evaluating contaminant releases from waste management facilities, toxic chemicals, and beneficial reuse of waste. The research plan also lays out a course for systematically improving quality assurance in models, applications, and, ultimately, decision-making under uncertainty. The central theme of the multimedia modeling research program is to establish a state-of-the-science software technology that can be utilized by both science communities to conduct research and to develop models and databases and regulatory communities to conduct assessments and ultimately cost-benefit analyses. Another unique aspect of this ORD program is the opportunity to develop a shared technology (inter- and intra-agency; see Leveraging section below) for environmental analysis that both facilitates the discovery and assimilation of new science (as models and databases) as they are developed to meet current needs and promotes operational consistency in the conduct of risk assessments across OSW programs.

The multimedia modeling research covers four principal areas of activity:

Science Advancement and Technology Integration: In the first phase of development, seventeen modules were incorporated into a multimedia assessment system. Additional work that is needed to continue addressing program office priorities includes evaluating and integrating the ground water to indoor air pathway, investigating ground water/surface water interactions, developing enhanced methods for incorporating subsurface heterogeneities, providing provisional toxicity values for a set of chemicals, and other priorities (see Table 1).

Current technology integration efforts are focused on refining and expanding the software infrastructure to include features and capabilities that directly facilitate the use of the technology to conduct research, model development, and site-specific risk assessments (while maintaining the national assessment capability). Despite the existence of a number of other models, site-specific multimedia modeling capability is needed to provide equivalent analyses at site-specific and nationwide scales, to evaluate nationwide applications, and to access uncertainty analysis/sensitivity analysis, database communication, and other features of the FRAMES software. Future activities are focused on assimilating new models into the system

resulting from the Science Advancement activities (e.g., development of indoor air models) as well as "legacy" models (existing models previously developed and currently residing outside the FRAMES system). As environmental assessments become more holistic, the technology challenge is to provide a software environment for the modeling community that facilitates the integration of models and databases representing all of the disciplines required to perform comprehensive risk assessments. The FRAMES modeling technology represents an infrastructure of core capabilities readily available to developers and users.

Quality Assurance: The focus of this work is on research and development of innovative methods for quantifying uncertainty and sensitivity in environmental decisions involving model applications. Addressing model sensitivity and uncertainty is critical to the application of comprehensive environmental models. Thus, the objective of this area of activity is to deliver methods and tools to quantify the full range of uncertainty and sensitivity in assessments and facilitate model evaluation and model validation. With the Supercomputer for Modeling Uncertainty and Sensitivity Evaluation (SuperMUSE) and related support software in place, it is possible to begin the development and application of specific methods for quantifying uncertainty and sensitivity. Initial efforts are underway to assess uncertainty and sensitivity in the context of national regulatory assessments.

Applications: This activity includes the conduct of specific assessments, evaluation of existing risk assessment and modeling approaches, development of new applications, assessment strategies, and regulatory approaches, and, finally, the development of user support functions including training workshops and efforts aimed at supporting users in executing exposure and risk assessments. Work in this area includes the application of multimedia modeling to selected assessments that will support activities as outlined in the section "ORD Program Shifts to Accommodate Emerging Research Priorities of OSWER." Included in these applications are assessment of needs, collection of data, formulation of scenarios, performance of assessments and communication of results.

Multimedia Decision-Making Science Questions

The following are key science questions identified for multimedia decision-making and reflect practical needs for technical support for risk assessment and cost-benefit analysis:

- What are the data needs and the nature of the assessment needs for beneficial reuse of waste?
- What are the environmental impacts of reusing waste?
- What are the best sampling and analysis approaches for electronics wastes?
- What is the environmental improvement associated with the reduction in use of priority chemicals?
- How should field sampling for vapors be undertaken?
- What is the nature of various modeling approaches to vapor intrusion?
- How can ORD best respond to the needs of the RCRA corrective action program?
- How can risk-based decision-making be made consistent and of assured quality

across OSW programs?

- How should multimedia risk assessments be improved for assessing exposures and risks through multiple pathways?
- What are the dominant areas of uncertainty in environmental models to be used in OSW's immediate and near-term decisions, and how can we best identify, quantify, prioritize, and reduce associated gaps in data and knowledge?
- How can a multimedia risk analysis be enhanced to more accurately reflect existing and anticipated engineering practices resulting from environmental management systems practices including waste management, pollution prevention, and resource conservation?
- How can we establish a model's validity, trustworthiness, and relevance?

Leveraging With Outside Agencies: The Multimedia Modeling Multi-Agency Memorandum Of Understanding

ORD recognizes the benefits of pursuing future FRAMES and multimedia modeling development within a multi-Agency collaboration and Memorandum of Understanding (MOU). Currently four Federal Agencies (Department of Energy, Department of Defense, Nuclear Regulator Commission, EPA) are collaborating on the further development of the core modeling technology. Leveraging provides EPA offices and collaborating Agencies with an ever-growing access to state-of-the-science models and databases being developed throughout the national environmental modeling community.

Progress to Date on Multimedia Decision-Making

Corrective Action: Corrective action technical support has been provided through the ORD technical support centers. Notable examples include providing support for evaluating vapor intrusion from a landfill that impacted a residential area (Region 9), assessment of ground water treatment using a novel biotreatment technology (Region 9), assessment of chlorinated solvent treatment using in-situ heating at a site in Region 4, and evaluation of hydraulic controls using ground water pumping wells and slurry walls in Region 10. A group of ORD scientists, engineers, and managers also provided significant input to the Agency workgroup developing guidance for vapor intrusion sites. ORD then organized a series of seminars to present the guidance and supporting guidance in three major cities.

Multimedia Modeling: Seventeen individual science modules have been organized to form a core risk assessment simulation capability. These models included five waste management unit contaminant release modules, five media-specific fate and transport modules, three food chain and food web modules, and exposure and risk modules for both human and ecological endpoints of concern. In parallel and necessary to the effort was the development of a modeling framework for integrating individual models (i.e., the seventeen science modules and their required inputs and outputs) and for allowing communication between modules and preparation of outputs (FRAMES v.1). The software, databases, and an extensive documentation set was made available to the public via the Internet by ORD's Center for Environmental Assessment Modeling (CEAM) (www.epa.gov/ceampubl). Additional products produced included an

evaluation of the ground-water and vadose zone components of the modeling system using laboratory and field data, and an update to the MINTEQA2 metal speciation modeling system incorporating an enhanced amorphous oxide database. An independent peer review of the seventeen science modules has been conducted and appropriate modifications made to the models. The inter-Agency Memorandum of Understanding group presented all the components of the approach at the 3rd Annual Federal Hydrology Conference in July 2002. This presentation introduced the concepts and approaches to a widespread group and led directly to a workshop in January 2003 on the critical issue of linking Geographic Information Systems (GIS) to simulation models. A third workshop was conducted in FY03 on uncertainty and sensitivity analysis in multimedia modeling that will address critical and universal problems in applying environmental models.

Beneficial Reuse of Waste: ORD has begun evaluating the major products derived from waste in the marketplace and will be working with OSW to refine the products of primary concern. ORD has also been working with OSW in evaluating the risks associated with a fertilizer derived from waste in the marketplace.

Outreach and Communication

Multimedia modeling products are transferred to OSW, the Regions, and other clients through the annual waste products list, presentations at the RCRA National Conference, and direct interactions with divisions of OSW, most notably the Economics Models and Risk Analysis Division. Version 1.0 of the 3MRA modeling system and its extensive documentation set are available by download from the CEAM technical support center.

Products from work redirected into resource conservation research are expected to be transferred in a similar manner. Corrective action products are transferred primarily through the technology support centers, but may also come from the waste products list, conference presentations, and through the National Service Center for Environmental Publications.

Critical Path to the Multimedia Decision-Making Long Term Goal

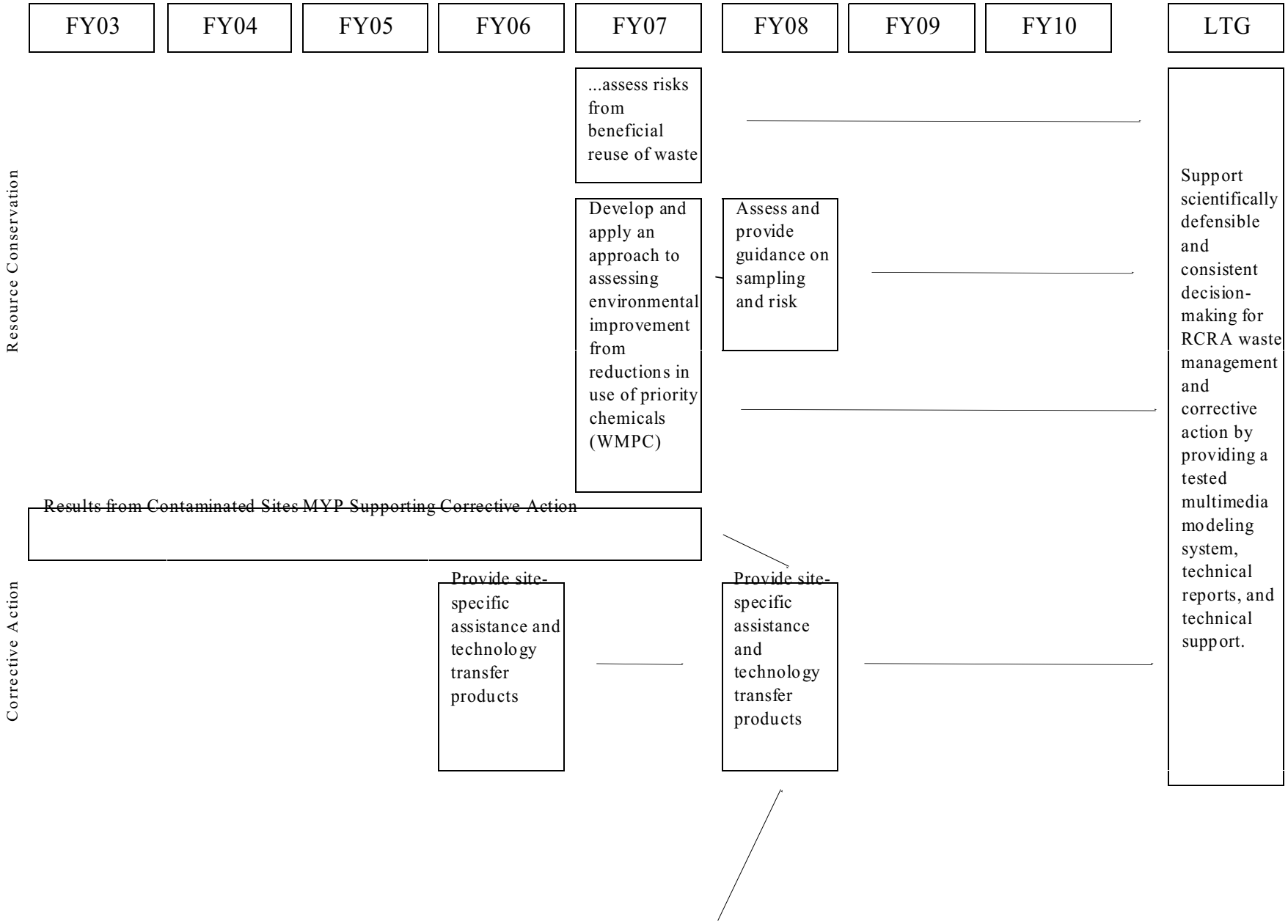
To meet our long-term goals and answer the science questions, we have developed annual performance goals (APGs) and annual performance measures (APMs). The flow of APGs to each LTG is shown in Figures 2 and 3 for Multimedia Decision-Making. The corresponding APMs/APGs are listed in Table 1.

The Multimedia Decision-Making LTG contains research that addresses resource conservation, corrective action and several aspects of multimedia modeling and its applications. APGs for each of these areas provide the critical path to achieving the LTG. Resource conservation is addressed through the three APGs (Figure 2). Sampling of electronics wastes is addressed in an FY08 APG. Beneficial reuse of waste is evaluated, and a risk assessment performed to complete an FY07 APG. Benefits of the reduction in waste minimization priority chemicals (WMPCs) are modeled through an APG for FY07. Corrective Action technical support and research is addressed by an FY06 APG that addresses technical support and mercury transformations in the ground water/surface water interface. Vapor intrusion of contaminants is

addressed through a series of products that will be completed in FY07 and feed into technical support provided by an FY08 APG. Related work on vapor intrusion and other aspects of Corrective Action performed under the Contaminated Sites MYP supports these efforts.

Multimedia modeling is addressed through a set of APGs (Figure 3) that advance the science of multimedia modeling and provide support for RCRA program needs. Although the work has been ongoing for several years, Figure 3 shows the sequence of APMs beginning in FY03. In this year estimates are given to estimate exposure, toxicity, and risk from exposure hazardous waste constituents. These estimates support the delivery of an enhanced 3MRA modeling system to OSW in FY03. In FY05 the modeling system will be completed. This modeling system, along with core uncertainty/sensitivity analysis capabilities and model evaluation strategies developed in FY07, will allow for evaluation of environmental impacts for both the new priorities and core research areas of OSW. From FY08 through FY10, the effort culminates to provide underlying science support for existing and new RCRA applications (FY08), extend the multimedia modeling system to capabilities to facilitate a broader range of exposure and risk assessment problems (FY09), and develop advanced methods and tools to quantify the full range of uncertainty and sensitivity in multimedia assessments (FY10).

Figure 2. Resource Conservation and Corrective Action Flow Diagram



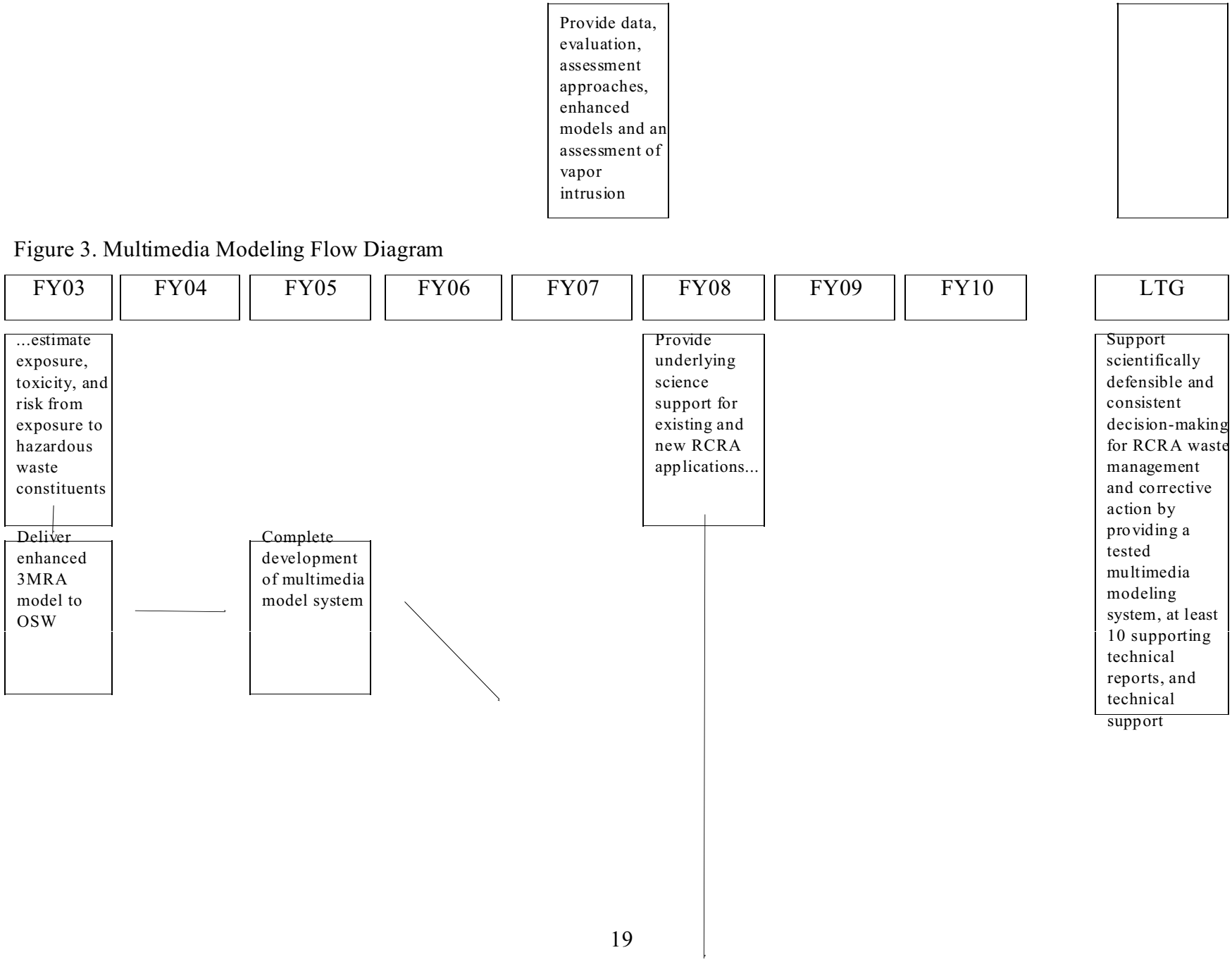


Figure 3. Multimedia Modeling Flow Diagram

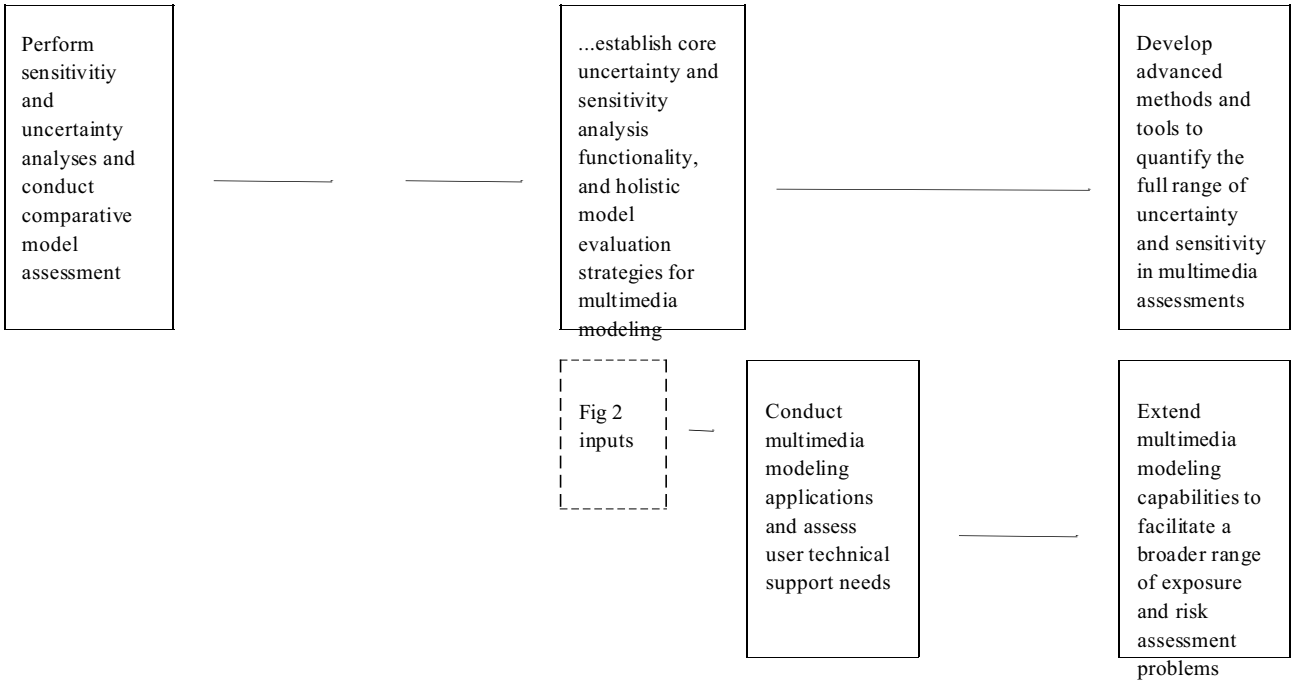


Table 1. Multimedia Decision-Making APGs and APMs

Multimedia Decision-Making Long-Term Goal: Support scientifically defensible and consistent decision-making at RCRA waste management facilities by providing a tested multimedia modeling system, technical reports, and technical support.				
Resource Conservation				
Assess and provide guidance on sampling of electronics wastes by providing at least four reports		FY08	Lab or Center	i/e*
	Literature search identifying typical components of electronics wastes	FY04	NERL	i
	Preliminary guidance on sampling electronic wastes	FY05	NERL	i
	Preliminary risk screening guidance for electronics wastes	FY06	NERL	i
	Final guidance on risk screening and sampling electronic wastes	FY08	NERL	i
~~Develop and apply an approach to assessing risks from beneficial reuse of~~ waste by providing at least four reports		~~FY07~~		
	~~Report on data gaps and needs for high priority products derived~~ from waste	~~FY04~~	~~NERL~~	~~i~~
	Collect and evaluate data and develop exposure scenarios for predictive modeling to support risk screening for selected products derived from waste	FY05	NERL	i
	Provide technical and regulatory support, consultation, and review on issues related to exposure aspects of risk assessments on beneficial reuse of waste	FY06	NCEA	i
	Apply predictive risk assessment model for selected products derived from waste	FY06	NERL	i

	Conduct national risk assessment for selected products derived from waste	FY07	NERL	i
Develop and apply an approach to assessing environmental improvement from reductions in use of waste minimization priority chemicals (WMPCs) by providing at least three reports		FY07		
	Provide modeling plan to measure benefits of RCC objective to reduce WMPC use by 50% by 2005	FY04	NERL	i
	Conduct a national risk assessment of current waste loading rates and projected reduction in use of 8 of 30 targeted WMPCs.	FY05	NERL	i
	Conduct an extended analysis of select WMPC chemicals using an integrated RSA, TSDE, UCPR sensitivity analysis methodology to identify key data gaps and greatest sources of uncertainty for land-based disposal of WMPC waste streams.	FY07	NERL	i

Corrective Action			
By 2005, provide site-specific assistance and technology transfer products that assist project managers in achieving environmental indicator goals for high priority RCRA Corrective Action sites that are documented through at least four reports.	FY06		
Biennial report summarizing technical support to regions and states for RCRA sites	FY03	NRMRL	i
Report summarizing sampling and analysis technical support to regions and states for RCRA sites for 2003, 2004, and 2005	FY06	NERL	i
Report on field study of mercury transformations at the ground water/surface water interface	FY05	NRMRL	i
Biennial report summarizing technical support to regions and states for RCRA sites	FY05	NRMRL	i
Provide methods to assess the significance of ground water/surface water interactions at contaminated sites – Contaminated Sites MYP	*FY05*		
Results from Contaminated Sites Reseach that support Corrective Action	*FY06*		
By 2008, provide site-specific technical assistance and enhanced technology transfer products that assist project managers in achieving goals for high priority RCRA Corrective Action sites, by providing at least two reports.	FY08		
Biennial report summarizing technical support to regions and states for RCRA sites	FY07	NRMRL	i
Final technical reports from STAR grants on the transport and fate of contaminants through the ground water/surface water interface and the consequent impact on aquatic ecosystem health	FY07	NCER	i
Provide data, evaluation assessment approaches, enhanced models and an assessment of vapor intrusion (VI) from contaminated ground water into indoor air through at least one analytical method, five reports and two models.	FY07		
Regional Methods Initiative work on indoor air analytical methods - Supplement to EPA Compendium Method TO-15 - Monitoring High Risk VOCs	FY03	NERL	i
Report/Issue Paper on the potential impact of volatile organic compounds in ground water on indoor air pathway of VOC transport.	FY04	NRMRL	i
Report on methodologies for sub-slab vapor sampling to evaluate vapor intrusion from subsurface contamination	FY04	NRMRL	i
Report/issue paper on recommendations for soil-gas sampling and gas permeability testing to evaluate vapor intrusion from subsurface contamination.	FY05	NRMRL	i
Review and critique existing vapor intrusion models	FY04	NERL	i
Provide prototype screening level model for the ground water/indoor air pathway for inclusion in the 3MRA modeling system.	FY04	NRMRL	i

	Provide results from an analysis of existing vapor intrusion models that illustrates their sensitivity and parameter values required to provide upper bounds on exposures	FY04	NERL	i
	Provide model for the ground water/indoor air pathway for inclusion in the multi-media modeling system.	FY07	NRMRL	i
Science Advancement-- Advancing the Underlying Science and Engineering for Multimedia Models				
APG 23: Provide methods, models, factors, assessments, and technical support to OSW, Regional, State, Tribal, and local offices to estimate exposure, toxicity, and risk from exposure to RCRA hazardous waste constituents through at least one report, provisional toxicity values and an enhanced method for multimedia modeling.		FY03		
	APM 77: Provide a report on the application of quantitative structure activity relationships (QSAR) and modeled exposure estimates in a risk-based chemical ranking and prioritization model supporting multimedia model development.	FY03	NCEA	i
	APM 94: Provide provisional toxicity values for 5 chemicals.	FY03	NCEA	i
	Enhanced methods for incorporating subsurface heterogeneities, including fractured rock into the 3MRA.	FY03	NRMRL	i
Provide underlying science support for existing RCRA applications and new methods, models, and databases for other RCRA applications (i.e., ground water VOC to indoor air and ground water/surface water interactions) through at least four enhancements to the multimedia modeling system and two reports.		FY08		
	Develop html-based exit level processor visualization capabilities.	FY04	NERL	i
	Develop detailed exit level processor capabilities for dis-aggregated risk analysis across sites and iterations, for both site-based and national population-based protection strategies.	FY05	NERL	i
	Cross reference to Corrective Action Theme: "Provide prototype screening level model for the ground water/indoor air pathway for inclusion in the 3MRA modeling system.	FY04	NRMRL	i
	Provide data and methods to support incorporating the impact of ground water/surface water interactions within multimedia modeling framework.	FY05	NRMRL	i
	Cross reference to Corrective Action Theme: "Provide model for the ground water/indoor air pathway for inclusion in the multi-media modeling system."	FY07	NRMRL	i
	Evaluate multimedia modeling system enhancements needed to expand capabilities to perform mining waste site assessments.	FY08	NERL	i
	Synthesis product: Develop extended abstract on existing capabilities, ongoing science needs, and future application areas identified with multimedia modeling for RCRA programs.	FY08	NERL	i

Technology Integration – Supporting Model Development, Evaluation, and Application

Deliver enhanced 3MRA to OSW to facilitate national risk assessments in support of regulatory development efforts and provide OSW/Regions with a version of this exposure and risk assessment modeling system that supports site-specific, cost-effective waste site management, documented through technical presentation and background materials for the SAB		FY03		
	APM 36: Deliver science-based enhancements to the 3MRA modeling system to support OSW's regulatory-based national risk assessments and the related conduct of site-specific risk assessments.	FY03	NERL	i
	Prepare final technical presentation and background materials for SAB review of the revised 3MRA methodology.	FY03	NERL	i
Complete development of the multimedia modeling system by providing a multimedia modeling system with enhancements for heterogeneities and field data.		FY05		
	Develop 3MRA Beta Version 2.0 with core capabilities including enhanced user interface, facilitative component (i.e., model & database) assimilation, distributed web-based computing, uncertainty/sensitivity analysis engines.	FY04	NERL	i
	Assimilate the Tools for Analysis of Contaminated Sites (TACS) developed under the Contaminated sites MYP into the 3MRA modeling system to provide a management system for field data.	FY05	NERL	i
Extend multimedia modeling capabilities to facilitate a broader range of exposure and risk assessment problems and new applications (e.g., RCRA CA) and incorporate advanced methods for uncertainty and sensitivity analyses by providing four enhancements to the multimedia modeling system.		FY09		
	Incorporate the Hydrocarbon Spill Screening Model into the multimedia framework to allow simulation of light-nonaqueous phase liquid problems.	FY05	NERL	i
	Incorporate evolved vapor intrusion model into multimedia modeling framework (*see Corrective Action Theme and FY07 APM for developing model for ground water/indoor air pathway*)	FY08	NERL	i
	Develop expanded capability within the multimedia modeling system to evaluate contaminant mass balance downstream of sources.	FY08	NERL	i
	Within the multimedia modeling system, provide the capability to perform mining waste site analyses.	FY09	NERL	i
Quality Assurance – Advancing Model Evaluation: Verification, Validation, & Uncertainty/Sensitivity Analyses				
APG 40: Perform sensitivity and uncertainty analyses on the 3MRA modeling system and conduct comparative model assessment and validation testing on components of 3MRA modeling system.		FY04		
	Select site for comparative model assessment of the 3MRA modeling system.	FY03	NERL	i
	APM 200: Perform comparative model assessment of 3MRA modeling system at selected site and prepare report.	FY04	NERL	i
	APM 197: Report on sensitivity and uncertainty analysis assessments for 3MRA modeling system.	FY04	NERL	i

Select, implement, and conduct experiments to establish core uncertainty and sensitivity analysis functionality, and holistic model evaluation strategies for multimedia modeling by providing software and two reports.	FY07		
Develop Windows-based, PC-Based, Supercomputer for Modeling Uncertainty and Sensitivity Evaluation (SuperMUSE) for conducting extensive environmental model simulations.	FY03	NERL	i
Develop supporting software tool set for parallelization and simulation of environmental models on PC-based supercomputing clusters, delivering prototype through CEAM.	FY05	NERL	i
Extend platform-independent software tool set for parallelization and simulation to 3MRA Version 2.0 for experimentation on PC-based supercomputing systems.	FY05	NERL	i
Incorporate capabilities to conduct regression/correlation based sensitivity analyses within multimedia modeling system.	FY06	NERL	i
Synthesis product: Develop report on application of supercomputing to multimedia national assessment strategies, with a demonstrated example of uncertainty analysis.	FY05	NERL	i
Incorporate global based sensitivity assessment methods (Regional Sensitivity Analysis (RSA), Tree-Structured Density Estimation (TSDE)) into the 3MRA modeling system.	FY06	NERL	i
Incorporate advanced statistical sampling methods into the multimedia modeling system (e.g., Latin Hypercube Sampling (LHS), Uniform Coverage With Probabilistic Rejection (UCPR)).	FY06	NERL	i
Incorporate prototype approaches for screening-level methods of sensitivity analysis within the multimedia modeling system (e.g., Morris' One At a Time' (OAT) Method and Andres IFFD Method).	FY07	NERL	i
Synthesis product: Develop extended abstract on global sensitivity analysis techniques and their efficacy in the examination of uncertainty in very high order models.	FY07	NERL	i
Develop advanced methods and tools to quantify the full range of uncertainty and sensitivity in multimedia assessments (e.g., parameter, model, and modeler uncertainties; screening, local, and global sensitivity analyses) by providing enhanced software and at least one synthesis product.	FY10		
Incorporate prototype approaches for variance-based methods of sensitivity and uncertainty analyses into the multimedia modeling system (e.g. Sobol's Method and FAST Method).	FY08	NERL	i
Conduct experimentation using a select set of models within multimedia modeling framework to demonstrate integrated parameter, model, and modeler uncertainty analyses.	FY09	NERL	i
Develop white paper on holistic model evaluation strategies	FY10	NERL	i
Synthesis product: Extended abstract on the application of screening level, local and global based sensitivity analysis techniques in the evaluation of uncertainty in very high order environmental modeling systems.	FY10	NERL	i

Applications – Applying Science and Technology for National, Regional & Site Scale Assessments

Conduct multimedia modeling applications and assess user technical support needs for OSW, Regional, State, Tribal, and local offices, industries, and research universities by providing at least two reports and two synthesis products.		FY08		
	Establish prototype for model distribution and user support network for 3MRA modeling system for Internet accessibility	FY03	NERL	i
	Report on user needs assessment for multimedia modeling with an emphasis on site-specific applications	FY04	NERL	i
	Conduct an application workshop for 3MRA Version 2.0 stakeholders and develop report on proceedings.	FY05	NERL	i
	Synthesis product: Extended abstract summarizing 3MRA technical capabilities and applications to national, regional, and site scale risk assessment problems.	FY05	NERL	i
	Cross reference to Quality Assurance Theme: APM 200 "Perform comparative model assessment of 3MRA modeling system at selected site and prepare report."	FY04	NERL	i
	Cross Reference to Resource Conservation Theme: "Conduct national risk assessment for selected products derived from waste"	FY07	NERL	i
	Cross Reference to Resource Conservation Theme: "Conduct a national risk assessment of current waste loading rates and projected reduction in use of 8 of 30 targeted WMPCs."	FY05	NERL	i
	Cross Reference to Resource Conservation Theme: "Conduct an extended analysis of select WMPCs using an integrated RSA, TSDE, UCPR sensitivity analysis methodology to identify key data gaps and greatest sources of uncertainty for land-based disposal of WMPC waste streams."	FY07	NERL	i
	Synthesis product: Extended abstract on continuing needs for user support in the application of multimedia modeling for national, regional, and site scale assessments.	FY08	NERL	i

* APM classification i = internal, e = external.

Waste Management Long Term Goal

Rationale behind the Goal

Wastes disposal in landfills or by incineration could cause harm to human health and the environment if proper procedures and safeguards are not in place. Research is needed to address a set of needs associated with these practices, so a goal was established that would address waste management and associated technical support[7]. This goal addresses ORD work in landfills, landfill bioreactors, leaching, hazard waste treatment, and combustion. These five research areas share the characteristic that they address approaches to waste disposal or treatment and thus are grouped together. The research and development performed under this goal has the objective of improving waste management by developing better approaches to landfill liners and covers, by reducing required landfill volume through use of landfill bioreactors, and by improving the characterization and testing of leachates and developing approaches for hard-to-treat wastes. Combustion research addresses this issue by seeking to develop improved approaches to monitor emissions that will lead to improved decision making on use of combustion and incineration. This work includes an element of resource conservation, where ORD work anticipated the OSWER need for research and development on landfill bioreactors.

> **Waste Management LTG: Improve waste management for industrial and municipal wastes to enhance sustainability by providing technical reports and technical support**.

The waste management research program addresses Agency issues associated with combustion, landfills, landfill bioreactors, leaching of landfill wastes, and hard-to-treat wastes.

Principal Areas of Research Activity

Landfills, Containment Systems, and Landfill Bioreactors: EPA is the lead Federal Agency responsible for industrial and municipal waste treatment and disposal. With regard to municipal solid waste, the country generates 8 billion tons per year. Increasing population density in coastal regions has stressed State resources for managing this problem. ORD is working with the public and private sectors to develop alternatives to managing waste. OSW has programmatic drivers requiring ORD research on landfills and containment systems. There is a rapid increase in the number of landfill bioreactors being built in the United States, both by large waste management corporations and by local governments. OSW is concerned about whether current landfill standards are adequate to ensure safe operation of bioreactors. ORD and OSW are evaluating whether significant releases of contaminants may occur from bioreactors as opposed to conventional landfills. ORD research is needed to determine what risk management options (e.g., improved system design, controls, or regulations) need to be

[7] This statement refers specifically to the Combustion Technical Support Center, which closed in FY03 owing to resource constraints and changing priorities.

applied to bioreactors. ORD support is also needed on liner technologies for two efforts: Industrial D Guidance, and Revisions to Solid Waste Landfill Criteria - Leachate Recirculation. Liners were originally designed for a 30 year service life. Since many landfills are nearing this age, there is a need to resolve the issue of liner integrity, and determine effective long-term performance monitoring options.

Leaching and Hazardous Waste Treatment: Industry legal challenges on landfill waste leaching issues (i.e., reliability of TCLP), prompted OSW to commit to evaluate the effectiveness of leaching methods. Research is needed on improved treatment options (including those with improved short- and long- term effectiveness) of hard-to-treat wastes (such as those bearing mercury, arsenic, and/or cadmium), to fill data gaps and provide scientific merit for future regulatory efforts (ORD research on mercury is described in the ORD Mercury MYP). This work may also assist OW in developing options for disposal of drinking water treatment residuals.

Combustion: Under the Clean Air Act, OSW must develop maximum achievable control technologies (MACT) regulations and evaluate and reduce the risks from combustion facilities. OSW must evaluate and permit many combustion facilities in a relatively short time. Emissions from waste combustion facilities have remained a public concern and a number of uncertainties remain about the risks posed by these facilities. The risks are potentially very high because:

- there are a large number of waste combustion facilities (almost 3,000);
- the emissions are toxic (includes dioxin, furans, mercury, lead, cadmium, and products of incomplete combustion);
- contaminants are dispersed over large geographic areas that often have large populations or produce important food products;
- exposures occur via multiple pathways and routes;
- response is immediate to long term for ecological damage; and
- high levels of contaminants emitted from waste combustion facilities have been measured in environmental media surrounding the facilities.

There are significant near-term efforts (rules and guidance) that need improved methods for monitoring stack gas emissions, such as the MACT Fast Track final rule, and guidance on "Collection of Emissions Data to Support Site-Specific Risk Assessments at Hazardous Waste Combustion Facilities," as well as proposed technical amendments to NESHAPS (standards for hazardous air pollutants for hazardous waste combustors). ORD is conducting research and providing consultations during the development, public comment, and implementation of these regulations. In addition, there is a continuing need by OSW and the Regions for improved methods to characterize emissions during permitting, and to address facility-specific design and operation technical issues.

Waste Management Science Questions:

- How effective are current stabilization processes for arsenic (As) and other toxic metals?

- How can the TCLP and other leach tests relate to actual leachate generation and to each other?
- What are the landfill bioreactor design, operation, and monitoring requirements and strategies for facility unit operation, to ensure the protection of human health and the environment?
- What are effective long-term control and monitoring strategies for landfill leachate, landfill gas extraction systems, and fugitive emissions?
- What easily monitored components of emissions can be used to predict more difficult-to-measure components (e.g., dioxin); and how can complex mixtures of organics in the stack gases be characterized with respect to risk assessment needs?
- What dioxin formation issues exist during combustion of hazardous wastes?

Leveraging with Outside Agencies for Waste Management Research

For cost-effective research support of the RCRA program, EPA leverages and coordinates work with other public and private organizations. Currently, EPA has the lead in providing regulatory guidance for solid waste disposal issues. Within EPA, the Office of Reinvention has worked extensively with bioreactor technology through the XL Program, in cooperation with States and private industry. Work with the Department of Energy (DoE) is focused on mixed waste landfills and mixed low-level radioactive waste. This is a program area not shared by EPA and for which DoE will continue as the lead. EPA is also collaborating with DoE to aid in the development of innovative technologies for monitoring emissions from high temperature thermal treatment systems and combustion devices. The Interstate Technical Regulatory Cooperation (ITRC) has proved to be a good forum for coordinating Federal and State activities, and for defining continuing research needs. ORD is working with the Association of State and Territorial Waste Management Officials (ASTWMO), the Solid Waste Association of North America (SWANA), the National Solid Waste Management Association (NSWMA), the private sector, and individual States in developing the landfill bioreactor technology and leaching characterization. ORD is also coordinating this landfill bioreactor research with the European Union Community and the Pacific Rim Countries. All these efforts assist the Agency's own research programs. There are many other outside research activities on the assessment and remediation of contaminated sites that provide products applicable to meeting RCRA Corrective Action and other goals. These activities are described in the ORD Contaminated Sites MYP.

Progress to Date on Waste Management

Landfills and Containment Systems: Work is being conducted on the physical/chemical stability of geosynthetic and composite clay liners to enhance the performance of landfill operations. In addition, in collaboration with a consortium of public and private sector organizations, field evaluations have been conducted on the effectiveness of alternative covers. This has included an evaluation of various cover materials in controlling the landfill water balance. This work is done in conjunction with work under the Contaminated Sites MYP.

Landfill Bioreactors: ORD has supported OSW in developing the Research Development and Demonstration (RD&D) rule for landfills. The recently-signed rule provides flexibility to the States to allow innovative approaches to management of municipal landfills. As a result of this rule, ORD and OSW are working with the States to assist them in evaluating the effectiveness of landfill bioreactors. In concert with OSW, Regions, States and industrial partners, a field evaluation of landfill bioreactors is underway. This has resulted in the development of a monitoring approach that the States can use in managing these sites. ORD and OSW conducted a workshop with key experts in the field to develop documentation on the state-of-the-art. This has served to identify data gaps in the research and identify issues from the stakeholders in implementation.

Leaching/Hazardous Waste Treatment: ORD has been conducting some mechanistic work to ID the most important parameters impacting the desorption/dissolution of metals, and how speciation relates to the mobility of arsenic. The ultimate goal is to put together predictive models. In addition, data has been collected on landfills throughout the country on parameters such as pH and metal concentration. This database will be important to focus on the chemical composition for refining effective leaching procedures. ORD provided support to OSW in the conduct of the SAB review on leaching methods. Finally, ORD has been conducting evaluations on the performance of treatment technologies for arsenic and mercury, the latter in concert with Goal 2 activities.

Combustion: Recent accomplishments have been directed at 4 areas: emissions of dioxin and furans from boilers and industrial furnaces (BIFs); development of surrogate indicator compounds for dioxin and furans; issues related to the interaction between bromine and chlorine in combustion systems; and the development of resonance enhanced multi-photon ionization (Jet-REMPI) as a real-time continuous monitor for dioxin, furans, and other combustion-generated air toxics of interest. This research has highlighted the critical importance of combustor deposits' influence on emissions of dioxin and furans. It has shown that trace amounts of bromine have the ability to dramatically influence the chemistry of chlorinated compounds within combustion devices. It has shown that variability in some relatively easy-to-measure compounds (such as chlorobenzenes) have the potential for accounting for the variability of difficult-to-measure compounds such as dioxin. It has also shown that Jet-REMPI has significant potential for use as a real-time monitor for air toxics that are present in the low ppt range.

Outreach and Communication

ORD has conducted workshops and published EPA reports on landfill bioreactors for the public and private sectors that describe the state-of-the-science. OSW and ORD have collaborated in the development of a landfill bioreactor web site. ORD is also collaborating with the European Union countries in mutually disseminating research progress. As the field implementation is expanding, ORD and OSW are coordinating their efforts with the States, including a relational database on bioreactor and a certification program for operators. ORD, OSW, ASTWMO, SWANA, and the private sector are working together developing the landfill bioreactor technology and leaching characterization. The containment research effort is strongly interfaced

with the ITRC in producing reports and conducting seminars nationwide. Reports are available from the National Service Center for Environmental Publications.

Critical Path to the Long Term Waste Management Goal

To meet our long-term goals and answer the science questions, we have developed annual performance goals (APGs) and annual performance measures (APMs). The flow of APGs to each LTG is shown in Figures 4a and 4b for the Waste Management LTG. The corresponding APMs and APGs are listed in Table 2.

There are four distinct areas of research within the Waste Management Long Term Goal: landfill bioreactors; landfills; leaching; and combustion/incineration. One or more Annual Performance Goals (APGs) for each area document ORD progress toward the LTG. Landfill bioreactor work to be completed in FY08 (Figure 4a) will provide at least four reports of technical information on the first generation of bioreactors. In parallel with this work, two APGs provide state-of-the-art technical documents to improve monitoring and control of landfill releases (FY03 APG24b), and an evaluation of long-term performance of liners and covers to improve estimates of the service life of landfills (by FY09). Leaching of wastes and management options for hard-to-treat wastes will be completed in FY08. Taken together, this work provides the basis for assessing improved future operation of landfills, either using a bioreactor approach, or liners and covers alone.

The fourth research area, Combustion and Incineration, has four research APGs (Figure 4b). The first APG, APG24a, provides in FY03 state-of-the-art technical documents and methods to improve monitoring of total organic emissions (TOE). In FY07, a research approach to evaluate emissions at RCRA Subpart X facilities will be provided, as will technical information on the use of advanced monitoring techniques and surrogate organic measures for dioxin. In parallel, fundamental results of research on metals and analysis and modeling of organics will be provided in FY05. Two APGs in FY03 and FY09 address provisions of technical support for health hazards from RCRA waste combustion facilities.

Figure 4a. Waste Management (Landfills, Hazard Waste Treatment, Landfill Bioreactor) Flow Diagram

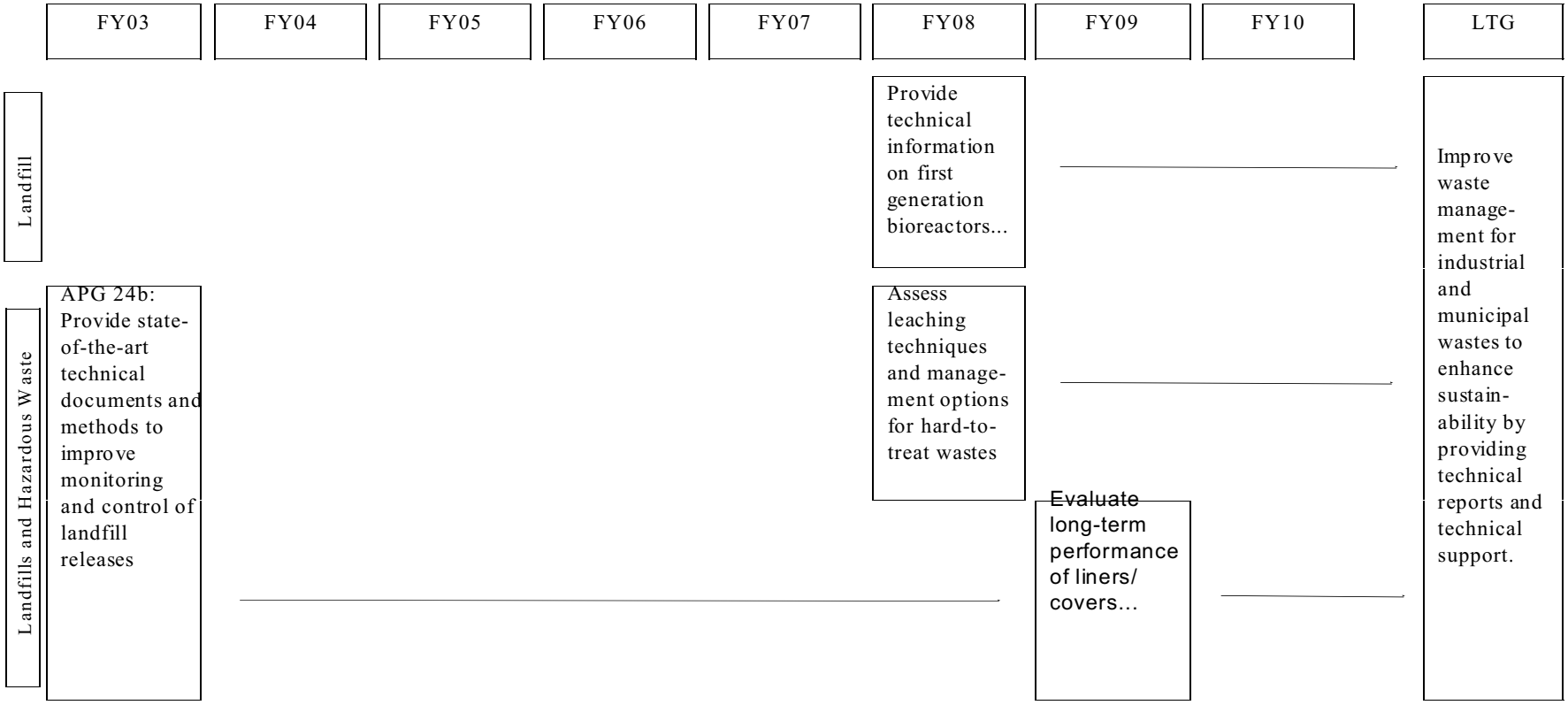


Figure 4b. Waste Management (Combustion) Flow Diagram

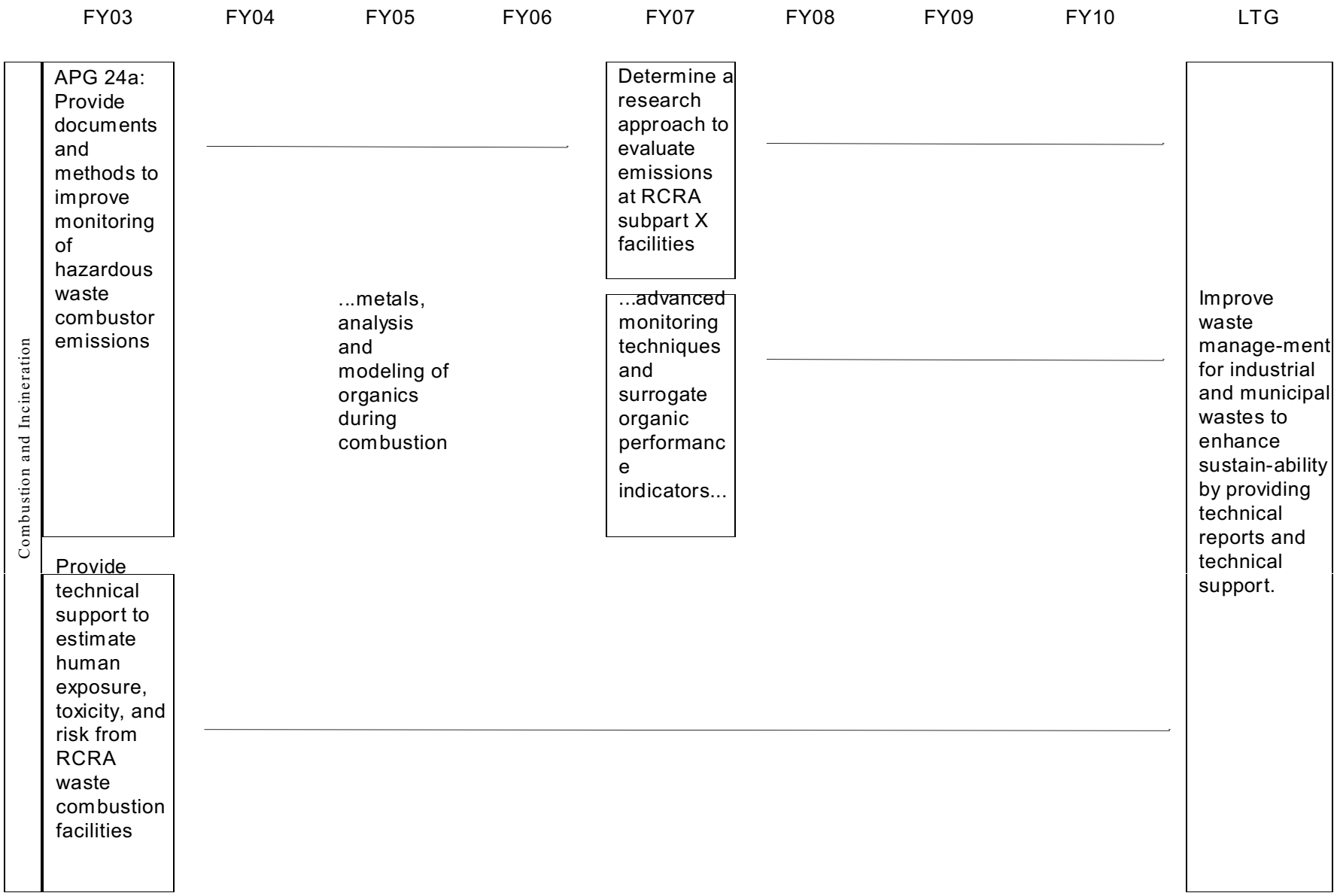


Table 2. Waste Management APGs and APMs

Waste Management Long-Term Goal: Improve waste management for industrial and municipal wastes to enhance sustainability by providing technical reports and technical support.			
Landfills, Containment Systems and Landfill Bioreactors			
Provide at least four reports of technical information on first generation bioreactor design, operation, and monitoring	FY08	Lab or Center	i/e*
APM 162: Interim field assessment of a landfill bioreactor system documenting the monitoring and control of landfill bioreactors to contribute to the life span of landfills by enhancing waste degradation (also under FY03 APG 24b)	FY03	NRMRL	i
Report on microbial assessment and solids analysis of landfill bioreactor operations	FY05	NRMRL	i
Interim report on landfill bioreactor design manual, characterizing the optimum operating and monitoring approaches	FY06	NRMRL	i
Synthesis Report on landfill bioreactor performance	FY08	NRMRL	i
APG 24b: Provide state-of-the-art technical documents and methods to improve monitoring and control of landfill releases for use by regulators, facility operators and other stakeholders to better protect human health and the environment	FY03		
Conduct field demonstration at 3 to 4 sites applying the proposed guidance in cooperation with ERT and EPA regions	FY02	NRMRL	i
Report and fact sheet providing guidance for evaluating landfill gas emissions and potential environmental risk to identify potential need for gas collection and control	FY03	NRMRL	i
Paper on assessment of fugitive gas emissions from waste containment facilities including landfill bioreactors based on field measurements	FY03	NRMRL	i
Evaluate long-term performance of liners/covers to improve estimates on the service life of landfills by providing at least four reports	FY09		
Report on the impact of root penetration upon the integrity of cover materials	FY03	NRMRL	i
APM 261 Report on physical/chemical stability of GCLs and CCLs (component of Contaminated Sites MYP - Containment)	FY04	NRMRL	i
Report on performance of conventional multilayer containment cover systems	FY07	NRMRL	i
Report on Construction Quality Testing for Improvement of Liner Performance	FY06	NRMRL	i
Evaluation of the performance of liners/covers including phyto-technologies	FY09	NRMRL	i

Leaching and Hazardous Waste Treatment				
Assess leaching techniques and risk management options for hard-to-treat wastes by providing five reports and one synthesis report.		FY08		
	Report on leach testing of mineral processing waste to improve the monitoring and containment of wastes	FY03	NRMRL	i
	APM 262 Report evaluating various leachant matrices used in leaching tests/methods, including the TCLP, to determine effects on the test results	FY04	NRMRL	i
	Report on the field performance of treatment technologies for mercury and arsenic (Hg work is component of ORD Hg MYP)	FY05	NRMRL	i
	Report evaluating the effectiveness of current waste stabilization processes for mercury, arsenic and lead (Hg work is component of ORD Hg MYP)	FY06	NRMRL	i
	Report of field data comparisons with laboratory leach tests.	FY07	NRMRL	i
	Synthesis Report on evaluation of leaching procedures and limitations	FY08	NRMRL	i
Combustion and Incineration				
APG 24a: Provide state-of-the-art technical documents and methods to improve monitoring of hazardous waste combustor emissions		FY03		
	APM 151:Complete a paper on revised total organic emissions (TOE) methodology and its applications to hazardous waste combustors (HWCs)	FY03	NRMRL	i
Provide the results of fundamental and applied research on metals and analysis and modeling of organics during combustion through reports from three grants.		FY05		
	Demonstrate a detailed mechanism of formation of polychlorinated dibenzodioxins/dibenzofurans (PCDD/PCDF) from ubiquitous, combustion generated hydrocarbons (Grant #R828191)	FY05	NCER	i
	Develop improved analytical techniques to identify or speciate total organic emissions (TOE) (Grant #R828190)	FY05	NCER	i
	Provide fundamental research data to broaden a comprehensive gas-phase model of the transformation of PCDD under a wide range of conditions (Grant #R828189)	FY05	NCER	i
Determine a research approach to evaluate emissions at RCRA Subpart X facilities by providing three papers.		FY07		
	Produce internal white paper on issues related to formation of air pollutants in high temperature Subpart X facilities, such as vitrification or gasification units, and propose a research plan to reduce risks from those types of facilities.	FY04	NRMRL	i

	Paper on issues related to metal aerosol/PM emissions from high temperature subpart X facilities	FY06	NRMRL	i
	Paper on air emissions from co-gasification of waste/biomass/coal	FY07	NRMRL	i
Provide technical information in the form of one paper and one draft guidance on the use of advanced monitoring techniques and surrogate organic performance indicators for incinerators		FY07		
	Publish paper on use of CEMs to measure organic surrogates for dioxin, and the application of those CEMs to assure compliance and optimize system operation.	FY05	NRMRL	i
	Develop draft guidance document for the use of Jet-REMPI for measurement of trace organics from incinerators	FY07	NRMRL	i
APG 2: Provide technical support to OSW, Regional, State, Tribal, and Local Offices to estimate human exposure, toxicity, and risk from RCRA waste combustion facilities		FY03		
	APM 76: Annual Report on Combustion Technical Assistance Center for 2002	FY03	NCEA	i
Provide technical support to OSW, Regional, State, Tribal, and Local Offices to estimate human exposure, toxicity, and risk from RCRA waste combustion facilities, that is documented through three annual reports.		FY04		
	Annual Report on Combustion Technical Assistance Center for 2003	FY04	NCEA	i

* APM classification i = internal, e = external.

4. Resource Trends for the RCRA Research Program

As described in the Introduction, the total annual RCRA MYP budget is about $10M. The allocation of resources for only the extramural part of the expected budget by long-term goal is shown in Table 3. These budget figures do not include resources from the Contaminated Sites (CS) MYP that address research applicable to RCRA (especially RCRA CA and waste management). We expect to have the capability and capacity for the work outlined in the RCRA MYP, barring loss of expertise that could occur through retirements. Our facilities and equipment are sufficient for accomplishing our goals. Resources for each LTG are anticipated to be approximately level through FY2010. Stable resources are needed to address RCRA problems, although increased integration of work between LTGs (with mutual benefit to all) is expected in the out-years.

Table 3 Resource Trends Table for RCRA*

Area	Emphasis in MYP Planning Window (FY03-FY10)
Waste Management (WM) LTG: Improve waste management for industrial and municipal wastes to enhance sustainability by providing technical reports and technical support.	Level funding expected.
Multimedia Decision-Making (MDM) LTG: Support scientifically defensible and consistent decision-making for RCRA waste management and corrective action by providing a tested multimedia modeling system and technical support to those who use the model to make environmental decisions.	Level funding expected. Increased integration of work with WM LTG in out years.

* Does not include research applicable to RCRA (especially RCRA CA and WMO) being conducted under the Contaminated Sites objective.

5. Potential Additions to the Research Program

OSW's RCRA Vision 2020

The purpose of this new research program would be to look ahead at how the management of wastes and materials containing toxic constituents (e.g., WMPCs) is likely to evolve over the next 10 to 20 years, and to address research needs that are critical to new management approaches. OSW produced a white paper in 2002 entitled: *Beyond RCRA: Waste and Materials Management in the Year 2020* (or "RCRA Vision 2020"), which is catalyzing further

discussion and projects on this topic. This is an important document for ORD to consider as we address how the impacts of toxic-bearing materials use can be minimized in order to protect human health and the environment, while minimizing the use of diminishing natural resources. The document presents a number of cutting-edge, important concepts. One is to move beyond a regulatory control approach to market-based incentives, to guide/stimulate more sustainability-oriented private and public decisions. Another is inclusion of the impacts of materials/products use and disposal when it considers how to enhance sustainability in the U.S. In the near term, a prospective ORD research program would have a new long-term goal to:

> **Provide innovative methods, tools, and technical support needed by EPA and other stakeholders for the sustainable production and use of materials and products.**

The research would expand upon that currently being done in ORD on process pollution prevention/source reduction, and on process waste management and associated risk assessment (e.g., using multimedia modeling) to address the following industrial ecology and sustainability issues:

- More sustainable approaches to pollution prevention and waste disposal, and
- Address the life cycle of materials and products, including those generated using process wastes (e.g., utility fly ash).

Specific research activities would focus on materials/products streams containing toxic constituents (e.g., treated wood), including those produced from waste streams. Research would include the use of life cycle analysis and other systems-analysis approaches, critical assessment of industrial ecology tools, exposure/effects multi-media modeling to determine the risks from material/product use and disposal, and evaluation of materials substitutes that utilize renewable resources, resulting in more reusable wastes and less human health and environmental risks. Other research topics could include development of an integrated waste management program for handling consumer electronics waste, which will involve metals reclamation, plastics recycling, and incineration (requiring research on combustion chemistry of bromine and brominated flame retardants). ORD has the expertise in this area as evidenced by its work on P2/source reduction and waste treatment and characterization. In addition, limited work is underway in selected areas that deal with risks associated with use of hazardous waste streams in products, such as ongoing research on the impacts of increasing mercury in utility boiler ash (see the Mercury MYP).

Improved Approaches to Waste & Materials Management

ORD's current Waste Management Research Program provides more cost-effective ways to treat and dispose of process waste streams. Due to resource constraints, this program is not addressing issues associated with "conventional" waste management in a manner that is providing all the information needed to meet OSW RCRA objectives. Expansion of the Waste Management research area is needed to:

- Enhance our understanding of leaching in various waste matrices and disposal environments.

- Conduct field tests on the effectiveness of varying bioreactor designs and implementation and utilization approaches under a wider variety of environmental conditions. These additional sites would provide a better understanding of the various operational approaches and the impact on performance.
- Conduct research on using inorganic sorbents to capture trace metal aerosols so that conventional particulate control devices can capture them.
- Conduct research on improved techniques of assessing and reducing risk due to combustor emissions of arsenic compounds by measuring and controlling the speciation of the arsenic from combustion sources.
- Conduct research on additional issues related to high temperature thermal processes, including investigations into organic emissions from catalytic thermal oxidizers.
- Develop new monitoring technologies that can simultaneously measure particle composition (e.g., metals, metal speciation), particle size distributions, and particle trajectories within combustors.
- Conduct Post Closure Reuse of RCRA Landfill Properties: The US has thousands of RCRA landfills that are closed or will be closed. Some of these properties are in areas where re-development is or will be occurring. An evaluation needs to be conducted regarding options for the safe re-development of these sites. This effort will evaluate the impacts of gas and settlement in closed landfills in considering alternatives for re-development/reuse of these properties. This will include management options such as considering light commercial businesses using free-floating structures and utilities. Work will be conducted in collaboration with landfill owner/operators.
- Conduct Technical and Economic Evaluation of Mining Recyclables from Landfill Bioreactors: With the recently-signed Research Demonstration and Development (RD&D) rule, more States will be considering the use of landfill bioreactors. Landfills that are operated as bioreactors are stabilized more quickly than conventional landfills. After stabilization, recyclables (metals, glass, and humic material) may be mined more readily. This project will investigate the technical and economic feasibility of pursuing mining at these sites.
- Optimize Waste Disposal and Reuse Options: This project will evaluate existing disposal methods for specific wastes, ranging from asbestos to hazardous liquids and municipal solid waste. It will evaluate the existing decisions on disposal of various wastes and identify alternatives to enhance reuse of the resource. For example, enhanced residential and commercial source separation could enhance recycling and degradation of wastes. In addition, where landfill bioreactors are implemented, it may be optimal to reduce or eliminate wastes such as asbestos to enhance the biodegradation of the wastes, improve energy recovery, and the potential for mining. This work will examine the disposal options of given wastes, and identify the optimal means to recycle the wastes or utilize it as an energy source.
- Evaluate the Impact of Recycled Products (e.g. foundry sands) on Soils: A variety of recycled materials have the potential to impact soils, including foundry

sands, mining wastes, and tires. These are used in a variety of products, including soil amendments, and inside and outside construction materials for residential, commercial or school-yard use. The latter might, for example, affect children via oral or dermal exposure. This work would examine the leaching potential of these wastes and the bioavailability as a function of the environmental conditions.

- Conduct research on the transport and disposal of carcasses of wild and domestic animals infected with chronic wasting disease.

This expansion would address the current LTG of the Waste Management program, as well as provide approaches to respond to resource conservation issues. The current Waste Management APGs (Figure 2, Table 1) would not significantly change, but would enhance the products and provide more robust waste management options.

RCRA Corrective Action

The principal focus of ORD's current RCRA Corrective Action program is to provide technical support to the Office of Solid Waste and Regions. In addition to providing rapid-turnaround scientific consultation, technical support activities will aim to identify and apply the latest scientific methodologies, models, and techniques to help the RCRA program meet its regulatory mandate to properly detect, assess, and cleanup any releases from waste management facilities. Limited RCRA research is being conducted to deal with priority RCRA CA problems. In addition, some research results from the Superfund program (see Contaminated Sites Multi-Year Plan) should be very relevant to the Office of Solid Waste's Corrective Action program (e.g., ground water/surface water and ecological risks). Work is needed, however, to address RCRA technical issues not covered by superfund and permanent cleanup issues. Such a program would fit in the RCRA CA Flow Diagram and have similar APGs to those described earlier in this document, but we would be able to address more sites and additional research topics, helping OSW to meet its goals more expeditiously and with a stronger technical basis.

Sampling and Analytical

The compilations of research needs submitted by OSW (Appendix B) and the Regions (Appendix C) included the following analytical methods needs that could be addressed by ORD by leveraging research conducted for Superfund and Office of Water, supplemented by relatively modest additional resources:

- The work proposed for sampling and analysis of electronics wastes could be expanded to produce similar products that address demolition debris.
- Speciation of mercury, arsenic, and selenium: ORD has an active research program applying "hyphenated" techniques for speciating arsenic in support of Superfund and Office of Water. These techniques could also be applied to the other toxic elements of concern to OSW. The proposed products would validate SW-846 methods for inorganic and organic forms of arsenic and selenium and mercury species in water and soils.

- Improved speciation of products of incomplete combustion (PICs), including coplanar PCBs: ORD is currently investigating novel separation and analysis methods for PCBs, as well as a powerful tool for identifying unknown chromatographic peaks (ion composition elucidation - ICE), which could easily be applied to PICs.
- Achieving detection limits low enough to use in environmental decisions (e.g., WMPC levels below water quality criteria (Regions), monitoring around waste derived product usage (OSW)): Current research on monitoring ambient levels (parts per quadrillion) of synthetic musks and current-use pesticides in water and biological tissue could be extended to selected WMPCs, brominated flame retardants and waste-derived products especially those of interest to multiple programs.

APPENDIX A: GPRA Goal 3 and Its Associated Objectives and Sub-Objectives

Goal 3: Preserve and Restore the Land.

Preserve and restore the land by reducing and controlling risks posed by releases of harmful substances; promoting waste diversion, recycling, and innovative waste management practices; and cleaning up contaminated properties to levels appropriate for their beneficial reuse.

Objective 3.1: Preserve Land. By 2008, reduce adverse effects to land by reducing waste generation, increasing recycling, and ensuring proper management of waste and petroleum products at facilities in ways that prevent releases.

> **Sub-objective 3.1.1: Reduce Waste Generation and Increase Recycling.** By 2008, reduce materials use through product and process redesign, and increase materials and energy recovery from wastes otherwise requiring disposal.
>
> **Sub-objective 3.1.2: Manage Hazardous Wastes and Petroleum Products Properly.** By 2008, reduce releases to the environment by managing hazardous wastes and petroleum products properly.

Objective 3.2: Restore Land. By 2008, control the risks to human health and the environment by mitigating the impact of accidental or intentional releases and by cleaning up and restoring contaminated sites or properties to appropriate levels.

> **Sub-objective 3.2.1: Prepare for and Respond to Accidental and Intentional Releases.** By 2008, reduce and control the risks posed by accidental and intentional releases of harmful substances by improving our Nation's capability to prepare for and respond more effectively to these emergencies.
>
> **Sub-objective 3.2.2: Clean Up and Reuse Contaminated Land.** By 2008, control the risks to human health and the environment at contaminated properties or sites through cleanup, stabilization, or other action, and make land available for reuse.
>
> **Sub-objective 3.2.3: Maximize Potentially Responsible Party Participation at Superfund Sites.** Through 2008, conserve Superfund trust fund resources by ensuring that potentially responsible parties conduct or pay for Superfund cleanups whenever possible.

Objective 3.3: Enhance Science and Research. Through 2008, provide and apply sound science for protecting and restoring land by conducting leading-edge research and developing a better understanding and characterization of environmental outcomes under Goal 3.

> **Sub-objective 3.3.1: Provide Science to Preserve and Remediate Land.** Through 2008, provide sound science and constantly integrate smarter technical solutions and protection strategies that enhance our ability to preserve land quality and remediate

contaminated land for beneficial reuse.

Sub-objective 3.3.2: Conduct Research to Support Land Activities. Through 2008, conduct sound, leading-edge scientific research to provide a foundation for preserving land quality and remediating contaminated land. Research will result in documented methods, models, assessments, and risk management options for program and regional offices, facilitating their accurate evaluation of effects on human health and the environment, understanding of exposure pathways, and implementation of effective risk-management options. Conduct research affecting Indian country in partnership with tribes.

APPENDIX B: Multi-Year Plan Research Needs Provided by the Office of Solid Waste

Summary of OSW Needs for ORD Research: FY 03 - FY 07
Dec. 23, 2002 (verified through subsequent discussion)

BACKGROUND:

This document updates OSW's statement of research needs, for use by ORD's Waste Research Coordinating Team (RCT) in planning current and future research activities. This is also intended for ORD's use in revising the "Multi-Year Research Plan" for RCRA (OSW and Regions) in a manner which addresses new programs, reflects greater cross-Agency coordination commensurate with the Agency's redefinition of its strategic goals, reflects research needs of our State partners, and identifies research plans for the out years (FY 07 and beyond.)

The research needs identified below fall under two major categories, each equally important. The first category consists of recent OSWER and Agency initiatives for which research needs are generally not yet funded (Resource Conservation Challenges) or are still being identified (Homeland Security topics.) The second category identifies ongoing core RCRA research which remain essential to the program and are generally not fundable under other programs or RCTs, such as waste-related Multimedia Science, Waste Management topics, and Correction Action technical support (which is not eligible for Superfund funding.) These categories include some unmet analytical needs which for convenience are also provided in a separate consolidated listing of analytical research needs.

This document also identifies key research and technical support needs which have been expressed by the Association of State and Territorial Solid Waste Management Officials (our State partners.) Many of these needs directly parallel or are identical to research needs identified by OSW and Regions, with an emphasis on basic research; increased technical support; and access to laboratory (including mobile laboratory) capabilities. The potential scale of these needs highlights the importance of carefully leveraging limited resources, and of considering how to "get the most bang for the buck."

To address these needs ORD will need to continue emphasizing a multi-program approach, and to leverage extensively with other RCTs and other programs, especially Superfund and Tonics. For example waste minimization and green chemistry topics concerning the top 30 chemicals should be a high priority for funding under the Pollution Prevention RCT; homeland security topics are expected to be funded through the new Homeland Security Research Center; and development of analytical methods should be closely coordinated with Superfund analytical funding.

Note also that some topics will require short lead times, and may be more amenable to a "technical support" or "program support" orientation rather than a "long term research" approach. In other words, some issues would benefit from relatively quick consultation with ORD experts, on the order of weeks or months, not years. However these issues are not traditional site-specific questions in predictable topic areas that have previously been the focus

of ORD's "technical support" hot-line centers. Nor are these issues work-group related activities such as rules or guidances that have previously been the focus of the "program support" category. Also, it is generally expected that these consultations would need to occur from a national perspective rather than focused on site specific topics. It is also important to note that such topics should be areas where ORD has unique capabilities and strengths, i.e. NOT be work that OSW could easily conduct through contractors.

General contact for referral to OSW technical/project leaders: Jan Young, 703-308-1568; See also project-specific OSW contacts, below. General contacts for referral to Regional technical/project leaders is: Paul Siemiski and Jeff Yurk, Region 6. See Jeff Yurk e-mail of 12-18-02 (Appendix C of this report) for specific Regional research/technical support needs.

EMERGING NEEDS AND INITIATIVES

1. Resource Conservation Challenge Program

A number of Marianne Horinko's priorities, which have also reached the Administrator's agenda for the Agency, fall under the purview of traditional OSW responsibilities. These include partnerships with states, municipalities and the private sector to encourage waste minimization, recycling, and "beneficial reuse" of wastes and products. The importance of these activities to the Agency is further highlighted by the Science Advisory Board's recent "Commentary on Industrial Ecology"(April 2002) in which the SAB emphasizes recycling, re-use and related topics in their recommendations to the Administrator. A number of these RCC initiatives are good examples of what have previously been called "pollution prevention" activities, and have previously been identified to the Goal 8 RCT for research support. However that separate process has not yet yielded the focus necessary to achieve dedicated research to these important multi-media, cross-program activities identified by OSW. It is imperative that the two RCTs work closely on these issues, and that the Pollution Prevention RCT recognize within their own priority-setting process that these are important research activities.

Key activities which would benefit from research or technical support include:

A. "waste to energy", i.e. a rulemaking which would allow wastes to be used where appropriate as a type of fuel in essentially closed systems–"gasification" systems;
B. partnerships with the private sector, states and localities to encourage waste reduction and recycling, e.g. in the areas of electronic wastes, carpeting,
C. "bioreactors" to manage municipal waste streams with greater efficiency. This already is a research activity, currently funded under the "waste management" category.
D. beneficial reuse" of waste derived products such as roadbed. This was a topic identified last year as a major unmet research need.
E. research into toxicities and exposures associated with disposal and recycling of cathode ray tubes and electronic wastes.

[see the complete 9/6/02 listing of "Project Descriptions for Reducing Waste and Recovering Energy" and see OSW web-site]

Research needs to address the above include:

(i) Research to better understand "green chemistry" approaches to identify environmentally friendly substitutes, especially for the highest priority 30 chemicals (from a listing of persistent, toxic & bioaccumulative chemicals,)
(ii) Research into design of environmentally friendly products,
(iii) Analytical methodologies to better characterize the fate of hazardous constituents during gasification,
(iv) Research on the content and environmental durability of the gasification frit produced,
(v) Development of source reduction and recycling opportunities for processes that generate hazardous wastes containing persistent, bioaccumulative, and toxic chemicals (PBTs).
(vi) Evaluating the stability, expected releases, and bioavailability of constituents in waste derived products. Such products contribute both to consumer exposures, as well as non-point source pollution of air and watersheds. OSW repeatedly receives queries on waste derived products, and research and tests on these uses would help with the evaluation of any risks associated with them. Predictive analysis of expected releases could be verified through field monitoring (in a manner analogous to NERL's current research on the environmental fate of personal care products and pesticides). Major examples of waste derived products, a.k.a. "beneficial reuses" include road bed materials (asphalt), cement additives, frit, cca-treated wood. Aspects of leaching research (see below) are related to this, particularly the leaching research on materials which are applied to land (e.g. roadbed, fill.)
(vii) Bioreactors: Work with OSW and SWANA to identify recent developments in research on "landfills as bioreactors " that is being conducted in a number of municipalities and states. Conduct research to identify optimal operating condition and parameters, for use in national regulatory revisions and guidances, and ultimately in state programs. OSW contact: Deborah Hanlon
(viii) Technologies for municipal waste management programs: Possibilities for technical evaluation include evaluation of ash aggregates for use in cement and non cement applications, evaluation of compost products as a filtering medium, evaluation of specified recycled products for the Comprehensive Procurement Guidelines, durability of synthetic liner systems, and evaluation of innovative recycling, treatment and disposal approaches being considered by local governments.
(ix) Electronic wastes: Needs include developing technologies for reducing barriers to recycling, identifying toxicities associated with electronic wastes, and evaluating worker exposures associated with shredding of electronic wastes. OSW contacts: Bob Tonetti, Kristina Meson.
(x) Development of source reduction opportunities for other hazardous wastes, e.g. combusted wastes, metals finishing.
(xi) Technological assessment of single-stream collection of recyclables and related processing systems; new uses for such difficult-to-market recyclables as certain plastic resins; feasibility of widespread commercial use of reusable containers. Research data would be used in conjunction with economic assessments to determine feasibility of single-stream collection systems.
General contacts: Thea McManus (RCC program in general), Rick Brandes (waste min. and pollution prevention)

2. Homeland Security: Waste Disposal and Analytical Issues

Homeland Security is a top OSWER priority, as it is for the entire Agency. The research in this area is being defined by the Homeland Security Research Center, based on needs coordinated with key program offices. The major areas where OSWER has to be fully prepared – and where the Waste RCT should extensively coordinate research needs with the Homeland Security Research Center:

a) safe, effective and efficient disposal of wastes from disasters/emergencies
b) analytical methodologies to characterize hazardous constituents in such wastes. Activities could include: identification of sampling strategies, target constituents, development of expedited, accurate procedures to characterize hazardous constituents.
OSW Contacts: Jim Berlow (general); Jan Young (analytical methodologies)
CEPPO (lead for OSWER) and OERR contacts

3. Enhanced Coordination with States on Their Research/ Technical Support Needs

The Association of State and Territorial Solid Waste Management Officials (a National association of our State partners) has provided a summary of technical assistance and research that States believe could be provided by EPA. These needs strongly reinforce the importance to the Agency of research in waste management technologies and resource conservation challenges, and also reinforce the importance of an appropriate degree of technical support activities. In general, the needs fall under the areas of fundamental research; technical support; and increased access to laboratory capabilities (including mobile labs). Selected highlights are summarized below. Again, many of these areas are identical to or closely aligned with RCC challenges (see above) and core RCRA research/technical support (see following sections).

- Research to advance the science of waste management and knowledge about risks posed by chemicals in the environment
- Research into health impacts by the use of hazardous wastes as products in manufacturing
- Research into long term stability of landfills
- Technical support to develop objective criteria for “environmentally preferable products”
- Guidance materials on “beneficial reuse,” performance of waste containment systems, liner design, waste-to-energy opportunities, calculating natural resource damages, innovative technologies
- Access to EPA laboratories to conduct research
- Real time field detection equipment, e.g. mobile or portable lab capabilities provided by EPA
- Technical assistance to review site-specific risk assessments submitted by owners/operators

CORE RCRA RESEARCH NEEDS:

4. Waste Management

Hazardous Waste Combustion

The Oct. '01 MYP remains a current summary of ongoing research needs and topics in the area of hazardous waste combustion. The reader is referred to the activities identified in the Oct. '01 MYP; see also the specific Region 6 needs expressed in this area (Jeff Yurk e-mail of 12-6-02), several of which may be topics with which CTAC can assist. Major areas of ongoing interest are:

- Dioxin/Furan emissions from boilers and from halogen acid furnaces. Continue work to identify significant D/F formation factors in boilers, ranging from operating parameters to design features, and identify key control mechanisms that are appropriate and that are cost-effective.
- Develop improved surrogates and CEMs for organic HAP/ dioxin/furan/mercury emissions and post combustion formulation. The surrogate approach is important for organic HAPs because current control mechanisms are limited in direct effectiveness (DRE, CO/HC limits) and because they do not supply the public with a sufficiently definite organic HAP profile.
- Technical support to permit writers and OSW, on stack sampling analysis, CEM and risk assessment, metals emissions, dioxin and other PICs, particulate emissions and operations parameters. Ongoing needs for CTAC support (site specific risk assessments) and for access to in-house expertise on implementing ORD emissions control methodologies.
- Develop improved speciation methods for distinguishing among and measuring the products of incomplete combustion (PICs) including coplanar PCBs. Full scale PIC testing to better understand formation dynamics; particularly post combustion PICs, including work on coplanar PCBs.
- Develop tandem procedure for discrimination of coeluting peaks
- Develop air deposition models especially the components dealing with vapor transport to surfaces, vapor/particle partitioning of semi-volatile compounds, wet versus dry deposition properties, and deposition of semi-volatiles. Finalize TOE test and dry gas models.
- Better understand mercury speciation at stack and fate and transport transformation.

OSW contacts: Hugh Davis at 703-308-8420, Sonya Sasseville/ Rosemary Workman at (703) 308-8725, and Karen Pollard at 703-308-3948.

Leaching topics:

The current MYP identifies valid, ongoing research activities concerning leaching topics. The reader is referred to the Oct. '01 MYP and the activities identified in that document. These activities support the following overarching science needs:

Understanding the chemistry of waste leaching more fully and improving our ability to accurately predict waste constituent leaching for a variety of waste types in a variety of waste management unit environments is a critical RCRA and CERCLA program need. Waste leaching prediction, through testing, is basic to distinguishing hazardous from non-hazardous waste (TC, listings, delistings, HWIR) and to deciding (especially for metals) when waste has

been adequately treated (LDR/BDAT, corrective action, CERCLA) or cleaned-up (corrective action, CERCLA). Well known problems with the TCLP (application to oily waste) have more recently been joined by illustrations of TCLP problems in evaluating highly alkaline waste (K088) and concern by industry about mimicking actual environmental conditions (mineral processing waste). In addition, some particular waste constituents, such as arsenic and other oxoanion-forming metals, mercury, and cyanides, appear to pose their own unique challenges when trying to understand and predict leaching. While some of these instances hold the TCLP to a higher standard than it was ever designed to meet, they also illustrate the program need (both RCRA and CERCLA) for a more broadly accurate leach prediction method either through laboratory testing, modeling based on fundamental chemistry and physics of leaching, or a combination of testing and modeling.

Finally, a more complete understanding of waste leaching is essential to ensuring environmentally sound reuse of waste, particularly where reuse involved placement of waste on the land, such as use for roadbeds, as fill, or in concrete. Basic research is needed to more fully understand issues related to waste matrices, constituents of concern, and management unit environment, such as: the effect of pH on leaching of different metals and organic constituents, liquid/solid ratio, redox potential, ionic strength of leachant, chelating agents, flow rate through waste, waste aging and degradation processes and factors affecting aging, and particle size.

Additional method and model development work is needed to build on existing work to incorporate the basic chemistry and physics of leaching into leach evaluation or prediction techniques. Issues include identifying critical factors that can be incorporated into a test, and which cannot, methods for scaling test results to field conditions, resolution of laboratory artifacts, such as colloid formation, and approaches to test method or model field or other validation.

In addition to the above general science needs, there is a current specific need for field validation of the important factors/analytical approach identified by Dr. Kosson and associates, and for protocols to help "routinize" the application of those factors and analytical approach by practitioners in the field.

OSW Contacts: Greg Helms, Larry Rosengrant

Waste Treatment

Hard-to-treat wastes are an area of concern that originally arose as part of our problems in the K088 Court Remand and as a high priority topic for the LDR Reinvention project. The two wastes currently with the highest priority are reactive wastes (e.g., reactive sulfides) and arsenic-bearing wastes. The arsenic issue is particularly important given the lack of viable treatment approaches and paucity of useful data on treatment results. (e.g., the UTS was established at the characteristic level by default). There is potential concern that some arsenic wastes are essentially going untreated.

- Provide proceedings from FY 01 Arsenic Scientist to Scientist meeting

The objective of OSW's LDRite project (which stands for LDR Innovative Technology Evaluation) is to establish a process by which innovative waste treatment technologies can be evaluated in terms of their usefulness in meeting the LDR treatment standards. Right now, there is no routine way to give feedback of a technical or policy nature to technology developers when they submit materials to OSW. This project requires to ORD to identify a person or persons who could help to evaluate the information submitted from a technical capability standpoint. We estimate between 5 and 10 submittals each FY.

Evaluate treatment alternatives for wastes that contain mercury, as part of an Agency-wide strategy for dealing with mercury in the environment. [OSW Contacts: Mary Cunningham, John Austin.]

> This subject should involve consideration of stabilization techniques in general, and should also involve consideration of any methods to handle mixed organic-inorganic mercury wastes (the objective would be to avoid combustion altogether).

Research the chemical dynamics and long term efficacy of emerging waste solidification and stabilization technologies (including cyanides and other organics). This was the subject of a pilot "State of the Science" survey project, which identified little ongoing research in this area. At this point, we need an evaluation of stabilization techniques under various conditions to determine if long-term immobilization is a realistic expectation. This is also an area that has been identified as a "technical support" area to OSPS. [OSW Contact: Elaine Eby]

Evaluate the cross media transfer of contaminants due to waste management and treatment technologies other than combustion (e.g. stabilization, thermal and solvent extraction technologies) particularly with respect to problematic compounds (such as mercury.)

OSW Contact: Hugh Davis

Liners

Evaluate the durability of synthetic liner systems to better understand their lifespan and long-term effectiveness in protecting the environment. Identify the most likely failure mechanisms, for use both in near-term installation requirements, and in modeling long-term probabilities of failure. Develop probabilistic modeling approaches to help identify long-term probabilities of failure under various Regional environmental conditions.

ORD and OSW are already coordinating closely with Superfund to help meet research needs in this area. Examples of RCRA-related research not funded by Superfund may include modeling long-term probabilities of failure, and projects concerning the failure of liners (as opposed to a land fill caps.)

OSW contacts: David Cozzie, Paul Cassidy

5. Multimedia Science

The current MYP remains an accurate statement of research needs to complete 3MRA for use in a variety of national, regional and site specific applications. The reader is referred to the Oct. >01 MYP and the activities identified in that document. Note also that future directions in the development of 3MRA depend significantly on the recommendations of the Science Advisory Board, who are conducting their review during FY 03. The schedule and efforts to improve the science, technology, and data for the 3MRA will depend on the outcome of these reviews and client needs.
Several specific ongoing needs include:

- Continue evaluation of techniques and approaches to verify and validate the multimedia and indirect exposure portions of fate and transport models, with a greater emphasis on identifying specific sites with multimedia data sources.
- Continue efforts to understand the transfer of constituent mass within the multimedia concept and to improve, where necessary, how the modeling system addresses mass balance in the context of intermedia fate and transport .
- Continued evaluation of the sensitivity and uncertainty in the modeling system to better inform users and decision-makers of the areas of greatest uncertainty.
- Provide tools to facilitate user interactions with the system that will allow the modeling system to be used for other risk assessments at the national, regional, and site scales; provide the capability to add science modules or pathways (for example, vapor intrusion); and provide capabilities for advanced uncertainty/sensitivity analyses.
- Incorporate into the modeling system the capability for addressing more comprehensive ecological population- and system-level analyses as well as cumulative risk for humans
- Continued development of subsurface fate and transport model and data by incorporating fracture flow and heterogeneous porous media.
- Continue efforts to enhance process information on hazardous chemical contaminant transformation, including half-lives and physio-chemical characteristics of transformation products.
- Incorporate enhancements of the MINTEQA2 thermodynamic database into the modeling system.

Contacts: Stephen Kroner (703) 308-0468, Zubair Saleem (703) 308-0467.

6. Corrective Action Technical Support and Research Support

- Continue and expand where necessary technical support provided to Regions through the Corrective Action Technical Support Center, and improve access to the Ecological Technical Support Center funded under Superfund.
- Continue work being conducted through Superfund and outside stakeholders to better understand the processes associated with natural attenuation of selected contaminants, and to identify appropriate circumstances for use of natural attenuation as a remedy.
- Continue work being conducted through Superfund and outside stakeholders to evaluate DNAPL fate/transport at selected sites, to evaluate treatment by permeable reaction barriers, and to identify improved options for remediation.
- Develop or evaluate innovative characterization technologies that allow for quicker and

more accurate assessment of contaminated sites, especially for the vapor intrusion pathway.

Contacts: Henry Schuver, Tom Rinehart, David Cozzie

SUMMARY OF ANALYTICAL METHODS RESEARCH AND DEVELOPMENT

In general, analytical methods development is a long-standing OSW program area which OSW is partially funding. OSW also works closely with TIO, the private sector, ORD/OAQPS, and others to encourage methods development by other stakeholders. There are a number of areas which would clearly benefit and be accelerated significantly with more ORD support. Several of these topics relate to new programs (e.g. RCC program) and others relate to ongoing core RCRA activities.

- RCC: analytical methodologies to better characterize the fate of hazardous constituents during gasification
- Homeland Security: analytical methodologies to characterize hazardous constituents in wastes from disasters/national emergencies. Activities could include: definition of sampling strategies, identification of target constituents, and development of expedited, accurate procedures to characterize hazardous constituents.
- Develop improved surrogates and CAMS for organic HAP/ dioxin/Furans/mercury emissions and post combustion formulation. The surrogate approach is important for organic haps because current control mechanisms are limited in direct effectiveness (DER, CO/H.C. limits) and because they do not supply the public with a sufficiently definite organic HAP profile.
- Develop improved speciation methods for distinguishing among and measuring the products of incomplete combustion (PICS) including coplanar PBS
- Sampling Method for Speciation of Stationary Source Mercury Emissions (check on status of NERL pilot scale testing and method development.)
- Method development/validation on speciation of mercury (OSW has this underway), arsenic and selenium
- Method development to identify “free” cyanide and to support OSW policy efforts concerning cyanide reactivity guidance
- Leaching topics: Method and model development work is needed to incorporate the basic chemistry and physics of leaching into predictive techniques. Issues include identifying critical factors that can be incorporated into a test, and which cannot, methods for scaling test results to field conditions, resolution of laboratory artifacts, such as colloid formation, and approaches to test method or model field or other validation.
- Development/validation of test methods for evaluating waste for pyrophoric properties and ignitability of solids.
- Sampling strategies to characterize demolition debris
- Methods and sampling strategies to characterize electronic wastes
- Others T.D.

Contacts: Jan Young (703) 308-1568, Greg Helms, Bob Holloway

OTHER IMPORTANT TOPICS (not funded through Waste RCT)

Human Health Science:

- Close coordination between OSW and ORD on IRIS and Heat updates
- Endpoint development, including QSAR/SAR methodology development for application to constituents not in IRIS or HEAT
- Review of RCRA Appendix 8 for potential chemical deletions.

Contact: Stephen Kroner, Monica Barron

Socioeconomic:

OSW Contacts for program relevancy reviews of STAR grants are Gary Ballad (703) 308-0475 and Lyn Lube

Chronic Wasting Disease: Regions V and VIII have prepared a proposal to conduct research into health and exposure concerns associated with the disposal of C.D. wastes. See Ron Lilac's 12-05-02 e-mail with the proposal attached. Contacts: Ron Lilac, Reg. VIII and Susan Mooney, Reg. V.

Mining Wastes:

The Multi-Year Plan identifies unfunded research needs to better characterize the environmental and ecological impacts of certain waste streams associated with the mining (non-utility) industry, e.g. acid water runoff, cyanides released from mining waste piles over time . Many of these impacts are experienced in waterways, and the need for research in this area is supported by the Office of Water and by Superfund programs.
OSW contact: Steve Hoffman

APPENDIX C: Statement of Research Needs from the Regional Offices

The Regions appreciate ORD's outreach effort and the invitation to help design research to better meet end user's needs. We realize that our focus in the Regions, which centers on applicability and utility of research, can vary from that of ORD's and the program offices. Working together, we will bridge this gap. The characteristics we feel are essential to every research project from an applicability and utility standpoint are; 1) study defensibility, 2) time efficiency from both an implementation of results standpoint and also a research deliverable standpoint , 3) flexibility to answer multiple variations of the question being researched, and 4) an ability to support solution identification as opposed to problem identification. In addition to the projects listed below we appreciate and continue to endorse the ORD's corrective action and combustion technical support centers.

A list of types of projects the Regions believe are applicable to their needs are listed below:

1) Improving speciation of air and water emissions inventories – It's imperative that we are able to have transparency and attribution profiling in our risk assessments and that begins with having defensible emissions inventories. An example of a project under this objective might be establishing microbial biodegradability rates of benzene and butadiene in aerated ponds at high (ppm) concentrations.
2) Provide bioavailability factors for metals across all media.
3) Provide metabolism factors for phthalates, PAH's, and other organics.
4) Expedite and provide more IRIS updates. A particular request has been made to develop toxicity information for polybrominated diphenyl ethers and one to finish the IRIS file on MTBE.
5) Provide a Nationally consistent set of acute toxicity benchmarks. If this is a long term project, provide a Nationally consistent methodology for selecting acute toxicity benchmarks from currently available databases.
6) Validate the deposition algorithm in the ISCST3 air model.
7) Validate the indoor air vapor intrusion model.
8) Provide speciation defaults for mercury, chromium, and nickel air and water emissions.
9) Provide analytical method for determining cyanide and sulfide waste reactivity.
10) Provide sampling protocol for subsurface vapor and screening criteria applicable to defining soil vapor contaminant concentrations that are protective for the indoor air exposure pathway.
11) Develop hyporheic zone sampling methodologies and screening approaches/criteria to evaluate whether current groundwater discharge is causing unacceptable surface water or sediment impacts.
12) Develop analytical methods to achieve detection limits low enough to use in environmental decisions. For example, PBT detection limits below water quality criteria.
13) Develop effective long-term containment remedies for sites which are technically impracticable to clean up. A portion of this may be to do a training for the Regions and States on what already exists on this front and get some idea of directions the end users could most use assistance in managing.
14) Assess how emissions from Subpart X high-temperature treatment units can be better characterized and controlled?

15) Assess how reliable are laboratory procedures and data results from stack gas emissions characterization in relation to EPA Methods currently being used. Specifically, 1) how are laboratories across the country actually implementing EPA Stack Gas Methods–e.g., with or without method modifications? and 2) if labs are modifying EPA Methods on a routine basis or even only in certain case-driven instances, what are the impacts of these method modifications on data usability specifically for risk assessment, permitting, and compliance evaluations?
16) Finalize TOE guidance.
17) Develop surrogate particle size distribution data sets or a methodology to generate them for different types of units which emit particles.